ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 TELEPHONE: TEMPLE BAR 3663

Vol. 179 No. 4660 LONDON, FRIDAY, MAY 20, 1955 Price 2s.

UNIVERSITY OF MICHIGAN
JUN 3 1955
ENGINEERING LIBRARY

MACHINING OF BACK-UP ROLL CHOCK

Steam from COKE BREEZE

COKE BREEZE has always been a *problem* fuel; cheap, and in abundant supply—especially at Steel Works and Gas Works where it is a residual material from their manufacturing processes—but of poor quality and low volatile content.

Now a system has been developed whereby the fuel bed of Coke Breeze is conditioned before reaching the main combustion zone of a furnace so that the maximum heat is extracted. The system is effective even when the Coke Breeze has a high moisture content, and it can be applied to existing steam plants without difficulty.

Known as the "Down Draught System of burning Coke Breeze," this system is described and illustrated in the leaflet (Right). Interested Engineers can obtain a copy or copies of this leaflet from our Main Offices at the address below, or from our local representatives.

Please address enquiries to:

JOHN THOMPSON WATER TUBE BOILERS LIMITED
JOHN THOMPSON GROUP

JOHN THOMPSON
WATER TUBE BOILERS LIMITED
WOLVERHAMPTON

ENGINEERING

An Illustrated Weekly Journal

Vol. 179 No. 4660 MAY 20, 1955

Leading Article

"Mods" 613

Weekly Survey

Power of the Future 614
Buoyant Gas 614
Private Locomotive Building 614
Manufacturing Automation 614
Competition in Pumps 614
Reserves for Progress 615
Consultations on Strikes 615
Surplus Tankers 615
50-Cycle Electric Traction 615

Principal Articles

Interpretation of Factory Act: House of Lords Decides Mechanical Grinders are not Securely Fenced 616
Institution of Naval Architects Spring Meeting: Sea Trials of a Motor Cargo Liner 622
Iron and Steel Institute Annual General Meeting. Gas Turbo-Blower for Blast Furnaces 623
Removing Dust from Flue Gases 625
Comparator for Gas-Turbine Blade Roots 625
The Physics of Transistors 628
Electric Dynamometer of High Precision 628
Increasing the Speed Range of Aircraft 631
100-MVA Reactor Controlled by Direct Current 633
Power for Emergencies: 50-kVA Set Driven by Gas-Turbine 636
Versatile Overhead Platform 637
Mobile Frequency Changers for H.M. Dockyards 637
Lorry-Mounted Excavator 638
Power Plant for a Cement Factory 638
Soldering Aluminium 639
Single-Tank Outdoor Circuit-Breaker 639
British Industries Fair 640
Prestressed Pre-Cast Manholes 643
Modifications to a Steam-Driven Pumping Plant: Raising the Efficiency of 40-year Old Plant 644
Vacuum Cleaner for Radio-active Dust 645
Linear Accelerator for Radio Therapy and Research 646
Lightweight Tractor 647
Compacting Granular Soils 648

Obituary

Major S. J. Thompson, D.S.O. 618

Letters to the Editor

Technical Staff for British Railways: Salary Ranges 619
National Water Supply 619

Book Reviews

Technical Report of the British Engine Boiler and Electrical Insurance Company, Limited 620
Technical Mathematics 620

Notes

Rolls-Royce Aero Engines 617
Aero Research Ltd. 21 Years Old 619
Science and Technology of Glass 619
Opportunities for Selling Electrictiy: Annual Luncheon of E.D.A. 620
Tema Harbour: Model Tests at Research Station 627
Measurement of Fluid Level in Wells 636
Grain Blower Adapted for Drying 637
Two New Rocket Motors 645

Personal 617, Commercial 617, Contracts 618, Books Received 621, Trade Publications 621, Launches and Trial Trips 630, Labour Notes 647, Notices of Meetings 648

★ ★ ★

Published every Friday by Engineering Limited 35 & 36 *Bedford Street, Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

★ ★ ★

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

"MODS"

IT is generally believed that an accountant is the best kind of expert to overhaul the organisation of a shaky business If it is an engineering business the engineers, it is said, are not able to take a wide enough view: the accountant's ignorance of technical details is to his advantage. Many engineers believe that the efficiency of an engineering works can be judged in a general way by considering the appearance and orderliness of the shops, much as a general casts his eye over recruits. A more reliable touchstone might be the firm's policy, or lack of policy, on modifications to design. For "mods." impinge on the work of every department—design, production and sales—and may be a major cause of wasted effort or, in other circumstances, a source of competitive strength.

Ideally, all modifications should originate with the maker rather than the user, since that would indicate perfect understanding of the users' requirements on the part of the maker. But even if such efficiency is achieved there may be a user who thinks he knows best, and demands changes to suit himself. Some products, of course, are modified when necessary almost solely on the initiative of the manufacturer. Consumer goods, including motor-cars, are in this category. The customers' needs and desires—even their human weaknesses—are studied continually, and design is improved with an eye on what other manufacturers are doing or are likely to do. In the case of motor cars, a significant part of this development is concentrated on non-mechanical aspects of design, and the work has to be dovetailed into the timing of periodical trade exhibitions such as the Motor Show. Every department of the firm which can contribute ideas for development must be allowed to play its part, and overall direction must ensure the optimum integration of the whole effort. When the scope for improvement in the engineering design is comparatively small—as it is to-day in motor cars—the aesthetic aspect of the design becomes correspondingly more important, because that is the sphere in which there is the greatest chance to compete more effectively.

The motor-car industry, of course, is a special case. There is much to be learnt from its remarkable ability to incorporate modifications without upsetting production. Although a critic might accuse the industry of attending to the whims of the user, there is sufficient evidence to show that, when cheap mass production is the goal, nothing is allowed to stand in the way. The early Ford dictum —that you could have any colour, provided it was black—was not only a succinct expression of an emphatic production policy; it was a powerful assurance to the customer that costs were reduced to rock bottom.

By contrast, there are many engineering firms where modifications to suit the customer are an essential part of business. With mass production it is almost impossible; with batch production it is allowable if there is sufficient cause; with unit production the issue is readily resolved. In this type of engineering there is often a two-way traffic of ideas between user and maker; indeed, the maker cannot go far without the co-operation of the user. The development of marine oil engines, for example, has derived strength in this way. From the purely engineering point of view this is a happy arrangement, permitting the designer to experiment with improvements and allowing the user to take part in work which will ultimately benefit him. But it requires careful preparation and shrewd judgment.

An unusual example of modification is described in this issue of ENGINEERING. It cannot be classed under the general heading of modifications during the course of production because it concerns a steam-driven pumping plant designed before the first World War. But it is a praiseworthy achievement. By a careful study of the design and operation of the old plant, allied to knowledge and experience of modern methods, an inexpensive modification has resulted in a saving of over 30 per cent. on fuel. Almost certainly there are other cases of plant which could be modified as effectively. A less creditable proposal, now in the news, is the plan which has been put forward to go ahead with the building of a bridge over the River Severn, in which considerable savings in cost are reported to have been suggested. Because the Government have refused to sanction the building of the bridge as originally planned, local authorities in South Wales and the west of England have been driven to consider the possibility of underwriting an £11 million scheme. In order to reduce the cost to an acceptable figure for this purpose, the original scheme would have to be modified. It is reported that the approach roads would be greatly reduced in length, single instead of dual carriage-ways would be provided, and the bridge would be for motor traffic only. Though the local authorities are to be praised for their initiative, the necessity for such a proposal is deplorable. If this compromise plan is undertaken it will earn the contempt of future generations. This is a modification of the worst possible kind. It is political engineering, not engineering of which we can be proud. Modifications are essential to development, but they must be planned by engineers, not dictated by expediency.

Weekly Survey

Cover Picture: *The interesting feature of the cover picture, which shows the shaping by means of a planing machine of the pressure-block for the backing-roll chock of a four-high cold strip rolling-mill, concerns the test bar seen in position in the bore of the chock. The chock weighs 10½ tons and is the bottom backing-roll chock, designed to carry a flood oil-lubricated roll-neck bearing for a heavy backing roll having a diameter of 53 in. and a barrel length of 56 in. The test bar is utilised to ensure, among other requirements, the perfect alignment of the side and other faces of the chock with the central bore. In the present case, the relative centres of the working-roll and backing-roll chock bores must be capable of vertical alignment to within 0·002 in. The modern strip mill is thus not only a powerful production instrument but also a high-precision machine.*

★ ★ ★

POWER OF THE FUTURE

In recent years the pace of technological progress has been nowhere more rapid than in the production of power. British engineers have been well in the forefront in all the newer lines of evolution. The annual report of C. A. Parsons and Company gives some indication of the extent to which they are contributing to the development of nuclear energy. The Parolle Electrical Plant Company, jointly owned by A. Reyrolle and Company and C. A. Parsons, have taken part in the design of Calder Hall and have collaborated with the Industrial Group of the United Kingdom Atomic Energy Authority in solving the special problems of industrial nuclear power. Parsons, who have home orders for the special dual-pressure turbo-generators, gas circulators and cooling-gas ductwork for atomic installations, are now looking for export opportunities. With a number of other companies possessing specialised knowledge and manufacturing facilities, they have formed a corporation which will concentrate on the design and construction of complete nuclear plants in any part of the world. They will work in close association with Head Wrightson and Company, with whom they have signed a long-term agreement on collaboration. Head Wrightson are experienced in the design and manufacture of heat-transfer equipment and have constructed experimental nuclear reactors.

It is believed that there are now more than 150 British companies manufacturing equipment for the various applications of nuclear energy, and all, including the dozen or so interested in the construction of complete power plants, are looking for export outlets. Many will be exhibiting at the Geneva exhibition in August, where a scale model of a complete reactor with ancillary equipment may be shown. It is expected that the Atomic Energy Commission will demonstrate the method of operation of a breeder reactor like that at Dounreay, and of a heavy-water reactor like the new E.443 at Harwell. A measure of the British determination to make the most of the export opportunities in this new and expanding field is that British applications for space at Geneva amount to 5,000 sq. ft. compared with 4,000 sq. ft. for the United States, 2,200 sq. ft. for Russia and 1,500 sq. ft. for France.

★ ★ ★

BUOYANT GAS

Gas is still a fuel to be reckoned with. Figures now available for production and consumption for the nine months ended December, 1954, show that the sales of gas to industrial and commercial users increased more rapidly than industrial production in general. Compared with an increase in industrial production of about 5 per cent., the industrial and commercial consumption of gas increased by 8·9 and 6·5 per cent., respectively. On the production side, the trend towards increased output of water gas relative to coal gas continues. Total sales of gas increased over the period by about 75 million therms. The total gas made increased by about 69 million therms (the difference being accounted for by stocks); of this increased output, water gas accounted for 46 million therms. In absolute terms the output of water gas is still small: 95 per cent. of material used in gas-making is still carbonised coal.

Gas sales to domestic users increased only slightly over this nine months period—by as little as 1·6 per cent. The relaxation of hire-purchase restrictions, however, and the general prosperity in the country, caused a large expansion in the newer kinds of domestic gas equipment. Sales of washing machines and water heaters more than doubled (including both cash and hire-purchase transactions). Refrigerator sales went up by nearly three-quarters and even gas space-heaters were up by nearly a quarter. Gas cookers on the other hand showed an increase of only about 9 per cent. It is thus apparent that the prospects for the light engineering industry making gas equipment for domestic users are tied partly to the trend of incomes and hire purchase facilities and partly to the sustained level of the housing programme which, although it has established a large demand for cookers, is not likely to increase that demand much above the present level. The effect of the recent re-introduction of hire purchase controls seems to be only temporary.

★ ★ ★

PRIVATE LOCOMOTIVE BUILDING

It is now clear that the private British builders of locomotives are to have an important share of the work in building the large number of Diesel and Diesel-electric locomotives required under the Transport Commission's modernisation and re-equipment plan. (Details of the contracts have yet to be announced; they were not given in the first stage reported in ENGINEERING last week.) Since overseas demand has fallen off considerably (causing redundancy in U.S. and European locomotive works) it is natural that the private builders should emphasise the importance of making the most of the present large home demand. Mr. J. B. Mavor, retiring chairman of the North British Locomotive Company, in his annual statement, draws attention to rumours current in Parliament and the Press that there is a proposal to order Diesel locomotives from abroad. He comments that it is hard to believe that " men of experience, with the interests of the country at heart. would put into effect anything so damaging to the export trade of the country."

At present, when the relative advantages of so many forms of locomotive propulsion and transmission are yet unresolved, the volume of development work undertaken by the locomotive builders is very considerable. North British are building a locomotive fitted with a gas-turbine made by C. A. Parsons. They are making their own Diesel engines under licence from the M.A.N. company of Augsburg (who built Dr. Diesel's original engine) as well as hydraulic transmissions under licence from the Voith company. So far, they have not fitted hydraulic transmissions to large main-line locomotives, but Mr. Mavor states that it is hoped to build 2,000-b.h.p. Diesel-hydraulic locomotives in the near future. Such locomotives have already operated successfully in Germany and may well win the day in competition with Diesel-electric types. Nevertheless, North British also have a stake in Diesel-electric development through their agreement with G.E.C., and can thus supply all types of locomotives.

★ ★ ★

MANUFACTURING AUTOMATION

The chairmen of three companies prominent in the field of electronics and instruments—Elliott Brothers (London), Limited, Lancashire Dynamo Holdings Limited and Powers-Samas Accounting Machines, Limited—have, last week, given useful information in their annual reports to shareholders on the development of automatic controls. Comments on the application of electronics to industry and on the reaction of organised labour to their introduction in manufacturing industry have been the subject of previous Weekly Survey notes. The company reports are evidence of the rapidity with which the change is taking place.

Mr. R. E. F. De Trafford, chairman of Elliotts, announces the formation of a new division to deal with nucleonic instrumentation—a field where remote control of the process is a pre-requisite of personnel safety and clearly one where electronic instrumentation has a major part to play. He also mentions guided-missile control, where the need is obvious enough, but comments that automatic control techniques are spreading to industries other than oil, chemicals and steel where they have already been extensively applied. Colonel C. T. Maxwell, chairman of Powers-Samas, confirms that considerable progress has been made in a very short time in the application of electronics to punch-card machinery, much accelerated in the case of his company by their association with Ferranti Limited. The development of electronics has created problems as well as opportunities for manufacturers of punch-card machinery, and the pooling of experience and research facilities which has been arranged may well serve as a pattern for the future development of this new shoot of one of the youngest branches of engineering. The greater proportion of the company's turnover still arises, however, from demand for conventional types of equipment—a demand which in their case is 5½ times greater than in 1938.

Clearly time is required for industry to assimilate the new methods, and much capital will be needed for their introduction. Yet the volume of the demand for electronic machinery is growing so fast that manufacturing capacity, which is being expanded everywhere, may be some years catching up. Mr. H. W. Bosworth, chairman of Lancashire Dynamo (the chairman-elect is Sir Percy Mills), placed much emphasis on the development of this group's stake in the electronic-control equipment industry—through Lancashire Dynamo Electronic Products, Limited, at Rugeley—and points out the gains in accuracy and quality that arise from the introduction of the machines. These three companies, along with a dozen or so others in the industry, show that progress is on the whole quicker than had been generally expected a year ago, and the momentum is increasing.

★ ★ ★

COMPETITION IN PUMPS

The rising output figures of the past few years give little indication of the difficulties which have beset the manufacturers of pumps. Output in the United Kingdom, which has grown from £21·7 million in 1951, to £33·7 million in 1954, reflects the increased requirements for hot-water circulation and process cooling in factories, homes and offices; for the expanding chemical and oil-refinery industries; for both industrial and marine boiler-feed; and for many other purposes from sewerage to refrigeration. Competition among the several hundred pump-makers has been intense, particularly for the simpler types of pumps for such purposes as hot-water circulation. Prices have been keen and profit margins often extremely low. Competition has been, of course, much less cut-throat for larger and more specialised pumps. In marine engineering, for example, the goodwill towards established manufacturers, the reliability and quality of whose products has been recognised for many years, is such that it is difficult for a new entrant to make much progress.

In the marine market the fall in the shipbuilding order book has caused considerable anxiety but, as the Rt. Hon. Viscount Weir of Eastwood points out in his annual statement as chairman of G. & J. Weir, Limited, inquiries have been more numerous in recent months. A substantial rise in output, accompanied by the fall in orders in 1954, had resulted in a reduction in the order book. The company's export performance was

remarkably good last year. Due partly to large deliveries made under a Kuwait contract for evaporating and distilling plant, total export deliveries increased by about 75 per cent. The company have been making considerable progress with the development of its sea-water evaporating and distilling plants: a method of ferric-chloride water treatment which ensures scale-free operation and hence maximum fresh-water output. The output of Drysdale and Company, Limited, a subsidiary of G. & J. Weir, who are in the more competitive market for small centrifugal pumps, exceeded all previous records in 1954. Drysdale's are, of course, strongly established makers of marine pumps and also undertake the largest land pumping installations.

★ ★ ★

RESERVES FOR PROGRESS

Mr. W. Lionel Fraser, chairman of Babcock and Wilcox, Limited, commented in his report circulated to the company's shareholders on the problems that arise when a leading engineering concern is faced with increasing competition in the range of their products that are relatively simple to make, in this case the more conventional type of boiler plant required for power stations and industrial plants. The company are faced with the dual task of making conventional plant at highly competitive prices, and of being in a position to undertake better than their competitors the more advanced and complicated installations. This they are achieving by spending very large sums on new equipment and machinery, on research and development and by building up large cash reserves. Nearly one-third of net profits for 1954 was allocated to reserves: £250,000 to a general reserve which now stands at over £6·3 millions, £250,000 to a contingencies reserve (now £1·25 millions), and £100,000 to a special research and development reserve. Mr. Fraser, commenting on the company's policy to invest in modern equipment "to combat intensifying competition, as well as the effect of rising costs and wages," argued that "now it is more than ever essential both to accelerate this process and to improve our underlying engineering strength." This is the price that shareholders in a first-class engineering concern must pay if its competitive position and profitability are to remain unimpaired.

Babcock and Wilcox are more deeply involved in technical change than, say, manufacturers of turbines and generators. They are one of the main contractors in the Calder Hall Atomic Power Station scheme and, like C. A. Parsons and Reyrolle, may be described as "at least waist deep in heavy water." Boiler design will be greatly affected by the peculiar requirements of the new fuel, and there is, quite apart from this development, a marked tendency towards very large high-pressure and high-temperature plants. Such a rapidly changing situation calls for the type of policy outlined by Mr. Fraser, and will doubtless favour the large well-equipped concern with resources sufficient to undertake the large and growing volume of research needed. The fact that atomic-power stations will be generating steam, and will require conventional steam turbines, is one that has been underlined more than once in recent months, though higher thermal efficiencies are likely to result from higher temperatures and pressures, perhaps through the use of new metal for blading, such as titanium. Britain's lead in power plant is a substantial one and, in to-day's competitive weather, most precious.

★ ★ ★

CONSULTATIONS ON STRIKES

Action which might be taken by the Government to minimise the dangers attending unofficial stoppages was referred to by Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, in an address delivered in London, on May 12. He considered that these strikes, with which, at present, the Government and the Trades Union Congress had considerable difficulty in dealing, constituted a great threat to the high level of prosperity this country now enjoyed.

Although the right to strike was not at stake, there was a definite danger that some workpeople would unthinkingly damage the continuance of full employment by pursuing claims for sectional advantages, regardless of the national interest, and possibly without, in some cases, taking full advantage of existing negotiating machinery. For this reason, the Government were proposing to discuss the problem with the Trades Union Congress, and with his Ministry's National Joint Advisory Council, on which both sides of industry were represented. It was nonsensical to suggest that the Government and their supporters wanted to interfere with the concerns of industry, but the Government did desire to carry a stage further their belief that the general body of employers and the trade-union movement were now "estates of the realm" and, as such, entitled to be consulted. The Government pledged themselves to consult the N.J.A.C. before making any plans to tackle the unofficial strike problem, whether by legislation or otherwise. A Conservative Government, however, would always give the earliest consideration to recommendations by the Council.

★ ★ ★

SURPLUS TANKERS

World oil consumption continues to climb rapidly, although in 1954 the growth in the United States was one of the smallest for the post-war years. In the rest of the world, excluding Russia, the increase was about 10 per cent. As Sir Frederick Godber, chairman of the Shell Transport and Trading Company, pointed out in his recent statement, this buoyant demand resulted in a rapid rise in short-term tanker freight rates, almost doubling them in the seven months to February, 1955. Even at the height of this activity when more than one-fifth of the tanker tonnage at sea was a short term charter, there were still over 1 million tons idle. This is a serious state of affairs, for tankers are still leaving the yards at the rate of 8 million deadweight tons a year and the total fleet is now about 40 million tons, compared with 16 million in 1939. A high portion of this tonnage is, of course, old and its retirement would help to bring stability to the tanker market. Mr. Claude C. Jacobs, chairman of the independent tanker operators John I. Jacobs and Company, in his recent statement drew attention to the unpredictable and often violent fluctuations in freight rates. Although the Persian Gulf rate at one time this year reached 81s. 9d. compared with 29s. 3d. in August, 1954, it is now down to 42s. 3d. as compared with 49s. 3d. in January, 1954.

Although the petroleum industry can look forward to a long period of prosperity before atomic energy becomes a commercial proposition, the future for tanker owners in the next two years will be difficult. Those owners like John I. Jacobs who have most of their fleet on long-term charters are in a strong position, but many of the independent operators are less fortunate. Of the world fleet, independent operators own about 20 million deadweight tons and the oil companies only 12 million tons (the remainder is Government owned). Of the new tonnage under construction, over 60 per cent. are for independent owners. Some of these, notably the large Greek owners, have been even more enterprising than the oil companies in building large tankers of 35,000 tons and over. Many, however, lack the resources necessary to maintain an efficient tanker fleet in a highly competitive market.

★ ★ ★

50-CYCLE ELECTRIC TRACTION

A conference organised by La Société Nationale de Chemins de Fer Francais on 50-cycle electric traction was held at Lille last week, during which the developments in this system which have taken place since the 1951 meeting at Annecy, were described in detail. In addition, an opportunity was provided to inspect the line between Valenciennes and Charleville, a distance of 80 miles, which has been operated electrically since July, 1954, and forms part of the trunk route between the north and east of France as well as Belgium and Lorraine. Although the passenger service on this route is light there is considerable freight and mineral traffic, which is at present catered for by 30 trains per day in each direction with an average gross weight of 925 tons. Tests, which have been undertaken with trains weighing up to 1,400 tons, are reported to have been satisfactory; and there is therefore some justification for the opinion that this system has greater possibilities than appeared likely when the initial experiments were undertaken.

The advantages of 50-cycle traction hardly need to be re-stated. The necessary power can be obtained from the national grid and transmitted at high voltage to a very small number of substations from which the relatively light collecting equipment is supplied. The cost of the fixed installation is therefore less than half what is necessary when direct-current is used. On the other hand (and this is the crux of the matter) the use of 50-cycle motors for traction purposes involves technical difficulties, which some regard as incapable of satisfactory solution. For that reason not only are both Co-Co and Bo-Bo locomotives used to accord with the traffic conditions, but five different electrical systems are being employed. In the case of the Co-Co locomotives these include converters, which will transform the single-phase energy into either three-phase or direct-current, while on about half the Bo-Bo locomotives conversion into direct-current will be effected by ignitrons. It is interesting to note, however, that about the same number of these locomotives are to be equipped with 50-cycle motors. The conference will be reported in a subsequent issue of ENGINEERING.

★ ★ ★

IMPROVING AIRWAYS PERFORMANCE

The news that British European Airways have made a net profit of £50,000 in the year to March 31, 1955, has coincided with the publication of traffic statistics for United Kingdom airways corporations in 1954. In the case of B.O.A.C. the year 1954 saw a slight setback in passengers carried, although cargo increased. There was a slight reduction in aircraft miles and hours flown, but the overall load factor went up from 64·3 to 64·5 per cent. Since the turn of the year, however, the Corporation's results have shown a significant improvement. The mileage flown has increased, and although passengers carried are still slightly down in 1955, compared with January, 1954, freight carried has increased by more than 20 per cent. and the load factor has gone up from 58 to 59·6 per cent.

In the case of B.E.A., passengers increased by nearly 12 per cent. on the year and cargo by over 7 per cent. Aircraft miles flown were slighly reduced but the overall load factor increased from 63·8 to 64·4 per cent. In January of this year the passengers and freight carried have shown a substantial increase on the same period of 1954.

Discussing the improved results of B.E.A. last week, Lord Douglas of Kirtleside, the chairman, estimated that each Viscount aircraft earns a profit of £36,000 a year. B.E.A. are now preparing specifications for an aircraft to replace the 46 D.C.3's still in its operative fleet. Mr. Peter Masefield, the chief executive, said that the corporation had in mind a turbo-prop machine which would be required in the early 1960's. The specification is expected to be ready in about six months with a timetable to give a delivery of about 12 machines in the early 1960's, apart altogether from any export potential which the aircraft industry might develop in the process of producing this aircraft for B.E.A.

INTERPRETATION OF FACTORY ACT

HOUSE OF LORDS DECIDES MECHANICAL GRINDERS ARE NOT SECURELY FENCED

By D. G. Fletcher Rogers

The House of Lords has decided that the ordinary mechanical grindstone as generally used is a machine that infringes the provision of the Factory Act 1937. It would seem that the effect of this decision is to make it illegal for workshops to use mechanical grindstones, and if employers do use them then they render themselves liable to criminal prosecution. The case that gave rise to this far reaching decision was an ordinary case of a workman using a grindstone and injuring the thumb of his right hand while so doing, a small accident typical of many that inevitably occur in modern industry.

It all started on November 27, 1951. Albert Harold Frost, a fitter employed by John Summers and Sons, Limited, was on night shift at his employers' steel works. In the course of his work he had to prepare a " key " from a metal bar about 4 in. long and in cross section about ¾ in. square. Frost had to shape one end of this bar to a semi-cylinder; he had done this sort of work before and going about it in his usual way took the work piece to the mechanical grindstone.

The grindstone was erected on a pedestal at a convenient height from the ground. The stone itself was nearly 2 ft. in diameter and was driven by an electric motor. The motor would be switched on or off as required by the operator, and when in motion the wheel revolved at about 1,450 r.p.m. All around the top and back of the wheel was a metal hood, and in front of it was a metallic rest on which a work piece could be laid. This rest was adjusted so that it left a gap between itself and the revolving stone of about ⅛ in. and the length of exposed wheel between the rest and the hood amounted to 6 or 7 in. It would be true to say that this particular grinder was a fair example of the thousands that are situated in the workshops and factories of industrial Britain.

To grind his key Frost held it to the moving stone with the body of it lying on the rest; both thumbs were on the top of the key and close to the portion being ground. To obtain the necessary semi-cylindrical shape the key had to be rotated upward against the run of the wheel and this caused Frost's thumbs to be very near to the stone.

How the accident happened was not satisfactorily explained. Frost himself thought that the gap between the rest and the wheel was too wide and that the key jammed in this gap pulling his thumb on to the wheel, but his employers were able to prove that this was impossible. Whatever caused the accident or in what manner it happened was not really relevant to the issue in the event; the important point was that Frost damaged his thumb owing to its contact with the moving wheel.

FENCING DANGEROUS MACHINERY

The injured man sued his employers for damages and based his claim against them alternatively in negligence or breach of statutory duty in that they failed to comply with section 14 sub-section 1 of the Factory Act 1937. This sub-section provides:—

" Every dangerous part of any machinery, other than prime movers and transmission machinery, shall be securely fenced unless it is in such a position or of such construction as to be as safe to every person employed or working on the premises as it would be if securely fenced: Provided that, in so far as the safety of a dangerous part of any machinery cannot by reason of the nature of the operation be secured by means of a fixed guard, the requirements of this sub-section shall be deemed to have been complied with if a device is provided which automatically prevents the operator from coming into contact with that part."

The defence was that Frost the Plaintiff had been the author of his own misfortune and so was guilty of negligence himself and further that the Defendants, i.e., Summers and Sons, had complied with the Factory Act and securely fenced the grindstone.

The case came for trial before Mr. Justice Jones at Chester Assizes on October 21, 1953, and he dismissed the claim finding that the real cause of the accident was the Plaintiff's own negligence and that there was no breach of statutory duty (i.e., breach of the Factory Act) on the part of the defendants. He also assessed the damages at £261 6*s*. in the event of the Plaintiff successfully appealing to a higher court. The Plaintiff took the case to the Court of Appeal and this Court reversed Mr. Justice Jones by a majority decision.

HOUSE OF LORDS DECISION

Summers and Sons now decided to take the case to the House of Lords, as it was considered that the Court of Appeal decision was of such moment as to require confirmation or otherwise by the Highest Tribunal in the land. In the House of Lords the judges, Viscount Simonds, Lords Oaksey, Morton of Henryton, Reid and Keith of Avonholm, decided unanimously in favour of Frost, though Lord Oaksey considered that as the trial Judge (Jones, J.) had found the Plaintiff negligent the House should not disturb that finding, and he (Lord Oaksey) would have awarded the Plaintiff half his damages. The House of Lords decision was given on March 24, 1955.

In both the Court of Appeal and the House of Lords the issues were simple and resolved themselves into a question, namely: " Was this grinding machine securely fenced as required by the Act ? " But to determine whether the machine needed to be securely fenced the Courts first had to decide that the wheel was a dangerous part of the machine. In deciding that this part was dangerous the House of Lords seemed to incline to the view that any wheel revolving at speed was dangerous and must be " securely fenced " as required by Sec. 14(1). Lord Morton was of the opinion that securely fenced meant fenced so that no person near it could get himself or his clothing into contact with the wheel and his judicial colleagues would seem to agree with this view.

For the Company it was argued most forcefully by their Counsel that the stone was as securely fenced as possible without rendering the machine useless, and it was further suggested that " as securely fenced as possible " was the real meaning that should be given to the wording of Sec. 14(1). But the House would have none of it, and the Judges indicated that the Act made it obligatory and absolute to securely fence without any modification; even if this rendered the machine useless, they could not upset the law as legislated by Parliament.

So the House of Lords gave the decision and it is now a criminal offence to require workers to operate the average mechanical grinder. When the author first explained this decision to a highly qualified and experienced engineer, he indicated doubts upon the good sense of the Judges responsible for it. But the decision is undoubtedly correct in law. Ten Judges have now ruled upon it (one similar case came before Mr. Justice Donovan and he held for the injured workman) and of these ten no less than eight have decided against the revolving wheel.

Accepting that it is now illegal to use mechanical grindstones " guarded " as the one was in this case, the next question is how wide is the application of this decision to be ? On general principles of law it would appear that all moving wheels of a like quality are covered by the decision. Thus, for example, in the shoe trade scouring, finishing and possibly polishing machines are all probably illegal unless their operating parts are so fenced as to render them virtually useless. It would seem that any moving abrasive wheel or knife which could damage a man who contacts it with his person or clothes is a dangerous part of machinery within the Factory Act and therefore illegal unless securely fenced. Lord Simonds said in an earlier case that the object of the Factory Act legislation was to keep the workman out of the machine, and that is what must be done even if it also prevents the work from getting in.

At this moment the Factory Inspectors should be visiting factories ordering machines to be stopped, and if their instructions are not complied with, then they should be prosecuting the offending manufacturers. As it happens, the Factory Inspectors are doing no such thing, and their policy is to do nothing. A spokesman from a local Inspector's office has declared " This decision of the House of Lords puts us in a very awkward position, but at the moment we have no instructions from London."

The effect of the decision is such that there are three courses open to the industrialist. He can either withdraw all offending machines, or endeavour to provide adequate guards, or urge the Secretary of State to take action under Sec. 60 of the Factory Act. This section empowers the Secretary of State to make special regulations to apply to all factories to modify or extend any of the provisions of the Act imposing requirements as to health or safety. Of the three courses the first two are impracticable, but the third can afford a solution. Representations should be made to the Factory Inspector's Department of the Ministry of Labour and failing satisfaction from that quarter to the Minister.

It is surprising that the modifying regulations have not already been made, for the first case outlawing the grindstone (mentioned above as the case before Mr. Justice Donovan) was decided on November 12, 1953. In that case the grindstone was 14 in. in diameter and guarded by a hood leaving an opening of 4 in. in width and 8¾ in. in height for applying work to the exposed wheel, which revolved at about 1,000 r.p.m. The tool rest was adjusted so that a gap of ⅛ in. lay between it and the stone which was badly worn. Mr. Justice Donovan found that the plaintiff was taking a risk but said that if the grindstone had been securely fenced he would not have been grinding at all.

USE OF OTHER MACHINES PROBABLY ILLEGAL

What are factories to do until the modifying regulations are made ? Short of stopping grindstones and machines of like character there is little that can be done. But it cannot be too strongly emphasised that by using an insecurely fenced machine the factory owner is liable to criminal prosecution, and in the event of an accident the Civil Courts will almost certainly condemn the industrialist in damages for the injured man. It seems, further, that to fence a grinder securely means that it cannot be used for any industrial purpose.

The penalties, in the event of proceedings being taken under the Factory Act, are: an order prohibiting the process involving the use of the offending machine—such an order would close a shoe factory entirely; financial penalties up to £25 on conviction and up to £5 per diem for each day after conviction during which the offending machine is being used; in the event of an accident causing bodily injury a fine of up to £100 may be inflicted in addition to any other fines. It should further be noted that as well as the company, any director, manager, secretary or officer of the company may be fined in the same way if he or they consented, connived, or facilitated by neglect the use of such machine.

PERSONAL

MR. H. T. RAMSAY, M.Sc., M.I.E.E., F.Inst.P., has been appointed director of the Safety in Mines Research Establishment of the Ministry of Fuel and Power. He succeeds MR. A. H. A. WYNN, M.A.(Cantab.), M.I.Min.E., who resigned on his appointment to membership of the National Coal Board.

The British Motor Corporation Ltd., Cowley, Oxford, has announced appointments and promotions to create closer co-ordination of the activities of the constituent companies. Included are MR. ARTHUR KEATS, O.B.E., chairman and managing director of Fisher & Ludlow Ltd., who has joined the board of the British Motor Corporation; MR. J. R. EDWARDS, a director of the Austin Motor Co. Ltd., who has been made director of manufacturing for the British Motor Corporation; MR. A. J. BURTON and MR. J. TATLOW, local directors of the Austin Motor Co., become supervisors of factories for the British Motor Corporation. In consequence, the following appointments have been made: MR. T. G. BRADLEY, local director of the Austin Motor Company, to branch manager, tractor and transmissions branch; MR. G. W. ROSE, O.B.E., T.D., A.M.I.Mech.E., to general manager, car division, Austin Motor Co.; MR. C. SPIRES, to branch manager, Morris Commercial Cars; MR. H. N. HOLBECHE to chief production equipment engineer, Midland area factories; MR. F. R. FORD to chief production planning engineer, Midland area factories; and MR. F. GRIFFITHS, to production development engineer, British Motor Corporation. Among technical appointments to the British Motor Corporation are those of MR. G. M. PALMER, a director of Morris Motors Ltd., to be technical manager, MR. W. V. APPLEBY, A.M.I.Mech.E., to be chief engine designer and MR. H. KING and MR. G. ARGYLE to be joint chief commercial-vehicle designers.

DR. F. LLEWELLYN SMITH, M.Sc., M.I.Mech.E., managing director of the motor-car division of Rolls-Royce Ltd., has been elected President of the Society of Motor Manufacturers and Traders, 148, Piccadilly, London, W.1, in succession to MR. A. B. WARING, chairman and joint managing director of Joseph Lucas (Industries) Ltd. Mr. Waring now becomes deputy President. MR. R. F. HANKS, M.I.Mech.E., is to continue as vice-president for a further year and MR. F. A. PERKINS has been elected a vice-president in succession to Dr. F. Llewellyn Smith. MAJOR-GENERAL J. S. CRAWFORD, C.B., C.B.E., M.I.Mech.E., M.I.Mar.E., has been re-elected for a third term of office as treasurer of the Society.

MR. T. A. CROWE, M.Sc., M.I.Mech.E., M.I.N.A., M.I.Loco.E., has been appointed chairman of the North British Locomotive Co., Ltd., Springburn, Glasgow, N.1, in succession to MR. J. B. MAVOR. Mr. Crowe will continue to occupy the position of chief managing director.

MR. L. M. BROADWAY, managing director of C. C. Wakefield & Co. Ltd., 46, Grosvenor-street, London, W.1, has been appointed to the board of the Port of London Authority by the Corporation of London.

MR. E. W. MEIKLEREID, C.M.G., at present Minister (Commercial) at H.M. Embassy in Paris, has been appointed head of the United Kingdom delegation to the High Authority of the European Coal and Steel Community, in succession to SIR CECIL WEIR, K.C.M.G., K.B.E., M.C., D.L., who is relinquishing this appointment. As stated on page 585 *ante*, Sir Cecil has been made a part-time member of the British Transport Commission.

ENGR. CAPTAIN G. VILLAR, C.B.E., M.I.N.A. M.I.Mar.E., R.N. (ret.), a director and general manager of John I. Thornycroft & Co. Ltd., Southampton, has been elected chairman of the Dry Dock Owners and Repairers Central Council for 1955–56. MR. P. GIFFORD, a director of D. & W. HENDERSON LTD., Glasgow, has been elected senior vice-chairman, and LT.-COL. T. EUSTACE SMITH, T.D., M.I.N.A., managing director of Smith's Dock Co. Ltd., junior vice-chairman.

MR. E. L. GETHIN, B.Sc.(Eng.), A.M.I.E.E., at present deputy chief contracts officer at the London Headquarters of the Central Electricity Authority, has been appointed supplies and production adviser to the British Transport Commission.

MR. C. RYDER, A.M.C.T., M.I.E.E., has been appointed chief engineer, instrument and meter department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, in succession to MR. T. W. ROSS, M.I.E.E., who has been appointed consultant to the chief electrical engineer. MR. J. C. DAWSON, B.Sc., A.M.I.E.E., has been made assistant sales manager, switchgear department.

MR. A. N. BUTLAND, O.B.E., B.A., B.Sc.(Eng.), A.M.I.C.E., assistant civil engineer, British Railways, North Eastern Region, has been appointed assistant civil engineer, London Midland Region.

MR. E. G. BRENTNALL, assistant signal engineer, British Railways, London Midland Region, Euston, has been appointed assistant signal engineering officer, in the chief signal engineering officer's department, British Railways Central Staff.

MR. E. V. SMALL, managing director of the B.T.H. Export Co., Ltd., has been elected to the board of directors of the British Thomson-Houston Co., Ltd., Rugby.

MR. H. G. HARLOW, B.Sc., M.I.E.E., who has been manager of the Leeds office of the British Thomson-Houston Co., Ltd., Rugby, since March, 1948, took over the managership of the Newcastle district office from May 16. He has been succeeded by MR. W. J. WILSON, A.M.I.E.E., who has been assistant manager at Leeds since April, 1954. MR. S. J. CLARKE, previously manager, Newcastle district office, is to take up another important appointment in the company. MR. A. B. FROST, has been appointed manager, Northampton lamp depot, in succession to MR. F. E. PERRY, who has left to take up an appointment with E.M.F. Ltd., Northampton.

MR. P. V. G. LINTZGY, has been appointed service representative of the Marconi International Marine Communication Co., Ltd., Chelmsford, Essex, at the Port of Lagos, West Africa.

MR. R. HENDERSON, O.B.E., has been appointed director of stores, Admiralty, in succession to MR. G. F. R. MARSH, C.B., as from July 18.

MR. R. W. BASSIL, A.M.I.E.E., has been appointed superintendent at the Deptford West generating station, London Division, Central Electricity Authority, in succession to MR. G. H. WHELTON, who retires this month.

MR. D. S. STEWART has joined the Bristol Aeroplane Co. Ltd., as "Britannia" development manager. MR. J. H. HOLT has been elected a director of Bristol Aero Engines (Western) Ltd., Vancouver, Canada.

MR. J. R. DUFF, A.M.I.Mech.E., has been appointed works manager of Blackburn (Dumbarton) Ltd., in succession to MR. L. MAXWELL who has left the company.

MR. J. J. COLLETT has been appointed training officer to the Council of Ironfoundry Associations, Crusader House, 14 Pall-mall, London, S.W.1.

MR. W. HAMILTON has been made sales manager of the Engineering Division of Sheepbridge Equipment Ltd., a subsidiary company of Sheepbridge Engineering Ltd. MR. W. J. RICKARD has been appointed Midlands-area engineer for Twiflex Couplings Ltd., Twickenham, another company of the Sheepbridge Group.

DAME MARY SMIETON, M.A.(Oxon.), is to succeed SIR HAROLD WILES as deputy secretary in the Ministry of Labour and National Service when Sir Harold retires on June 25.

★ ★ ★

COMMERCIAL

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have opened new branch premises in Great Western-road, Gloucester. The manager is MR. I. R. MORGAN. New branch premises have also been opened in White House-road, Ipswich. The Manager is MR. A. WHITE.

VAUGHAN ASSOCIATES LTD., 4 Queen-street, Curzon-street, London, W.1. (Telephone: GROsvenor 1571-2), have been appointed sole selling representatives and servicing agents for the copying lathes produced by GEORGE FISCHER LTD., Schaffhausen, Switzerland.

RILEY STOKER CO. LTD. announce that in view of their extended activities in recent years, their name will be changed, as from June 1, to RILEY (IC) PRODUCTS LTD. The head office address and telephone number remain unchanged, namely, 19, Woburn-place, London, W.C.1. (Telephone: TERminus 2622). The company is a member of the INTERNATIONAL COMBUSTION GROUP.

The London office telephone number of ABELSON & CO. (ENGINEERS) LTD., Coventry-road, Sheldon, Birmingham, 26, has been changed to RELiance 7081. The office is at 60-62 Clapham-road, S.W.9.

BENNIS COMBUSTION LTD., Little Hulton, Walkden, Manchester, announce that following an agreement with TODD OIL BURNERS LTD., 130, Leadenhall-street, London, E.C.3, they are able to execute complete oil-burning installations for shell-type and water-tube boilers.

THE CONSOLIDATED PNEUMATIC TOOL CO. LTD., 232, Dawes-road, London, S.W.6, have entered into an agreement to take over virtually world-wide representation for the HEMBORN range of dustless dry-drilling equipment.

ROLLS-ROYCE AERO ENGINES

40 Years of Development

The name Rolls-Royce was already well known for high-quality motor cars when the company first entered the aero engine field. To-day, it is equally celebrated in the aircraft industry. It may not be generally realised, however, how much of the company's total effort is devoted to this type of work. Mr. A. F. Kelley, B.Sc., A.M.I.C.E., A.M.I.Mech.E., M.I.P.E., director and general manager (manufacturing) Aero Division, Rolls-Royce, Limited, speaking at the Gas Council industrial luncheon at Chesford, near Kenilworth, on May 10, said that it was in 1915 that Sir Henry Royce was persuaded, rather against his will, to design and build an aero engine. To-day, more than six times as many people are employed by Rolls-Royce on aero engine work as on the production of motor cars. The first Rolls-Royce aero engine was the Eagle, which was of the V-12 type, with two banks of six cylinders. It delivered 225 h.p. on its initial run, and by the end of the 1914–18 war had been developed to produce 360 h.p. During this time the Hawk, Falcon and Condor engines, all the V-12 type, were produced, but it was the Eagle which achieved the greatest fame. Some 5,000 were produced, and Eagle engines were used to power the Vickers aircraft in which Alcock and Brown made their pioneer Atlantic flight in 1919.

Engines of the V-12 type continued to be produced, and in 1925, supercharging was introduced on the Buzzard engine, which delivered 800 h.p. Subsequent models of this engine produced 1,900 h.p., and it was basically the same type, with an output of 2,530 h.p. that powered the aircraft which, in 1931, achieved the world speed record. One engine which will always be remembered is the Merlin, the design of which was commenced in 1933, the year in which Sir Henry Royce died. The first type test of the Merlin engine gave a h.p. of 625; it was finally developed to 2,000 h.p. the bore and stroke remaining the same. Most of the experience in the installation of radiators, air intakes and exhaust systems for the Merlin engine was obtained by flying a Rolls-Royce Kestrel engine in a German Heinkel HE. 70 which the company purchased. On the successful development of the Merlin engine the Government decided that production facilities should be increased, and the Rolls-Royce factories at Crewe and Glasgow were built. In addition, the Ford Motor Company at Manchester and the Packard Motor Company in America undertook the erection of new factories for manufacturing Merlin engines. By the end of the war over 150,000 Merlin engines had been produced.

Rolls-Royce first became interested in jet propulsion in 1938, and in 1940, manufacturing facilities were made available at Derby for the producers of the Whittle engine. In 1941, actual manufacture of the Whittle engine was started. The first Rolls-Royce jet engine was the Welland, which gave a thrust of 1,700 lb. for a weight of 850 lb. In 1943, the company started to design a new jet engine of the straight-through flow type, with a centrifugal compressor; this was the Derwent, of which over 9,500 have been made. The names of rivers for Rolls-Royce jet engines were given to express the idea of flow. Following the Derwent came the Avon engine, an axial-compressor type which produced, in its original form, 6,000 lb. of thrust; development raised this figure to 7,500 lb. and 8,050 lb. in subsequent models. The Avon engine has been type tested at 9,500 lb. thrust with reheat, and in a more advanced model at 10,000 lb. without reheat.

Experiments with propeller-turbine engines were undertaken by the Rolls-Royce company in 1943, when a Derwent jet engine was fitted with a propeller drive; in this form it was known as the Trent. In 1945, two of these engines were installed in a Meteor aircraft, which was the first propeller-turbine machine in the world to fly. Developments in this sphere continued, the

Dart propeller-turbine engine of 1,000 h.p. being introduced in 1945. The Dart has since passed a series of type tests at 1,400 shaft horse-power plus 365 lb. of thrust.

The Dart 506 engine is now in production and higher powers under climbing and cruising conditions are now possible. This engine will be succeeded by the Dart R.Da.6, which has a take-off power of 1,600 shaft horse-power and even better climbing and cruising power than the 506, with a further reduction in fuel consumption. Development work has also been proceeding for some time on the Conway engine. Details of this engine are classed as confidential under the security restrictions, but it can be said that it is a turbo-jet incorporating the by-pass principle, and combines high thrust with fuel economy.

* * *

CONTRACTS

Turbo-Generator Sets. The Manitoba Hydro-Electric Board, Canada, have placed an order, valued at over 1 million dols., with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester, 17. The contract covers the 3rd and 4th 33,000 kW, single-cylinder turbo-generator sets for a new power station at Brandon, Near Winnipeg. It brings the total capacity of the generating plant ordered for this station to 132,000 kW. Each turbo-generator set for Brandon will run at 3,600 r.p.m., and will incorporate single-cylinder turbines designed for a maximum output of 33,000 kW. The initial steam conditions are 600 lb. per square inch gauge and 825 deg. F., exhausting to condenser at 28 in. mercury. The generators will be 13,800-volt machines of the hydrogen-cooled type, using hydrogen at a pressure of ½ lb. per square inch.

Air Liners. The British European Airways Corporation have placed further orders for 11 Viscount air liners with VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1. Ten will be Viscount Major V. 802 aircraft fitted with developed ROLLS-ROYCE Dart 510 engines of 1,600 s.h.p. They will have a normal cruising speed of 318 miles an hour and accommodation for 65 passengers. The remaining aircraft will be a V. 701. The new air liners are due to be delivered in 1957. Trans-Australia Airlines have also ordered three additional Viscount air liners. The new aircraft will be of the Viscount 700 D type and will be powered by ROLLS-ROYCE Dart 510 engines of 1,600 s.h.p.

Steel Pipes. Orders for steel pipes ranging from 20 in. to 24 in. in diameter, and up to 40 ft. in length have been received by the SOUTH DURHAM STEEL AND IRON CO. LTD. These orders comprise 55,000 tons of steel pipes, valued at £2,500,000 from the Iraq Petroleum Co., for the conveyance of oil, and a second order, worth £800,000, for 15,000 tons of steel pipes, received from the Aramco Overseas Co.

Oil-Filled Cable. The Central Electricity Authority have placed with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., on behalf of the North West, Merseyside and North Wales Division, the contract for supplying, laying, jointing and terminating 16,800 yards of 0·2 sq. in., 132-kV, three-core oil-filled cable. Where the cable is laid in ducts, the conductor area will be increased to 0·25 sq. in. The cable will form three feeders, each 5,600 yards long, between Agecroft switching station and Bloom Street substation, Manchester. The maximum design dielectric stress is 100 kV/cm.

Airfield Control Radar. Following closely on a recent announcement of a contract from the South African Air Force for Decca type-424 airfield-control radar, DECCA RADAR LTD., 1-3 Brixton-road, London, S.W.9, announce that a contract has now been placed by the Union of South Africa Department of Transport for the supply and installation of the Decca type-424 control radar at Durban National Airport. This equipment enables an operator to identify aircraft approaching the airport and give precise directions for approach and landing in all weather conditions.

Gas-Producer Plant. A further order for a GI two-stage gas-generator plant for the production of clean gas has been received from the English Steel Corporation Ltd., River Don Works, Sheffield, by the INTERNATIONAL FURNACE EQUIPMENT CO. LTD., Aldrich, Staffordshire. This is the third plant of this type to be installed at these works, two others having been put in about 18 months ago.

Power Transformers. Two contracts for the supply of power transformers to the United States have again been awarded to FERRANTI LTD., Hollinwood, Lancashire. One contract is for an 8/10 MVA 110-kV three-phase transformer for West Fargo, North Dakota, and the other for a 10-MVA, 110-kV three-phase transformer for Yankton, South Dakota. Both are part of the Missouri River basin project. The value of the contract is 130,000 dols.

Television Transmitters. The British Broadcasting Corporation have ordered two pairs of television transmitters from MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, for their proposed alternative-programme service and in anticipation of the allocation of frequencies in Band III by the Postmaster-General. The vision transmitters are rated at 7½/10-kW output power, while their sound counterparts are of 2/2½-kW output. Delivery is expected to be effected in the latter half of 1956.

Helicopters. The British European Airways Corporation have placed an order with WESTLAND AIRCRAFT LTD., Yeovil, Somerset, for another Westland S-55 helicopter. This is in addition to the two Westland S-55 machines which have already been delivered to the Corporation for use on their new passenger service between London Airport and the centre of London, scheduled to start later this year. The S-55 is the civil version of the Westland Whirlwind which is in service with the Royal Navy and the Royal Air Force. Capable of carrying eight passengers and their baggage, in addition to its crew of two, it has an all-up weight of 7,500 lb. (3,420 kg.).

Road Construction. A contract has been signed between the Persian Government and JOHN MOWLEM & CO. LTD., 91 Ebury Bridge-road, London, S.W.1, for the reconstruction and extension of the main-road system in Persia. The present road system covers nearly 4,000 miles and the sum involved in the work is about £30 million.

Cargo Steamers. An order for two single-screw steam-turbine cargo liners has been given by Furness, Withy & Co. Ltd., to VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, Westminster, London, S.W.1. The vessels will be built at the Naval Yard, Walker-on-Tyne. They will have a displacement of 11,500 tons on a draught of 29 ft. 6 in., and a service speed of 15½ knots. The principal dimensions are length, between perpendiculars, 470 ft., breadth moulded, 63 ft. 2 in., depth moulded 41 ft. The propelling machinery will be supplied by the PARSONS MARINE STEAM TURBINE CO. LTD., and is designed to develop 7,700 s.h.p. Both vessels will be similar to the "Pacific Northwest" (1954) and "Pacific Reliance" (1951).

* * *

Obituary

MAJOR S. J. THOMPSON, D.S.O.

Boiler-Making and Soldiering

It was with regret that we learnt, as reported in our issue of May 6, of the death on April 30 of Major Stephen John Thompson, past-President of the Institution of Mechanical Engineers. He was in his eightieth year, and it was only during 1954 that he had retired from the governing directorship of the John Thompson group of companies with which he had been actively connected for over sixty years. As one of the five grandsons of the original founder of the family engineering concern, he had taken an early interest in the design and manufacture of boiler plant and, after having acted as assistant manager of works, had been admitted as a partner as long ago as 1901.

Stephen Thompson received his general education at the Wolverhampton Grammar School and his training as an engineer at the works of the family business. He travelled widely as a young man before the turn of the century and, with his father, undertook considerable researches into the requirements of boiler plant while working in China, Japan, Australia and India. Early in this century he went to Germany and returned with the patents of the Durr boiler which the company began to make in 1903—their first introduction to water-tube boilers. His interests in the business were not wholly confined to technical matters, and as early as 1914 Major Thompson was instrumental in initiating a profit-sharing scheme for the staff and workpeople; this scheme operated until the firm was formed into a public company in 1936. In 1921 he began an unemployment fund and sick club; he also introduced family allowances payable to the lower-paid workers employed in the firm.

Outside his business he had seen active service with the Royal Artillery in the first World War and as a battery commander of the 241 Regiment, R.A., was awarded the D.S.O. He had been a member of the old Volunteers before they became the Territorials and he continued this association for nearly 50 years, finally becoming Honorary Colonel of the 119 Field Regiment, R.A., T.A., in 1939. He was also Honorary Colonel of the 672 H.A.A. Regiment, R.A. For 29 years he was a governor of the Royal Wolverhampton School and of the Royal Hospital in that town; he was a deputy Lieutenant of Staffordshire and had also been High Sheriff of the county.

Major Thompson was a corporate member of the Institution of Mechanical Engineers from 1902, and was prominent in assisting in the formation of the Midland branch in 1921. Following a period of service as a member of council he became President in 1942. His address was entitled "Boilers—Past and Present" and in it he reviewed boiler progress made in the 50 years he had then been connected with their construction. He was made an honorary member of the Instution in 1947. As a keen historian of engineering, he had collected together a number of relics of James Watt, including drawing instruments, tools and measuring instruments. These, together with a George Stephenson painting and other material, he presented to the Institution. He was also a member of the Institute of Marine Engineers and of the American Society of Mechanical Engineers.

* * *

LOCH GLASHAN PROJECT

New Hydro-Electric Scheme in Argyll

The waters of Loch Glashan, Argyll, are to be harnessed under a scheme prepared by the North of Scotland Hydro-Electric Board. The scheme, which will produce about 17,600,000 units of electricity annually, is required to help to meet the rapidly growing demand for electricity in the Kintyre and Knapdale areas. The loch lies in the hills behind Lochgair on Loch Fyne.

The natural catchment area of Loch Glashan is four square miles and, by means of diversion aqueducts, use will be made of the rainfall on a further 20½ square miles, including part of the catchment of the River Add which flows into Loch Crinan. All the water will be collected behind a dam, 1,100 ft. long and 45 ft. high, to be built at the outlet of Loch Glashan. From the dam, water will be led by a tunnel and pipeline 5,500 ft. long to a power station with an installed capacity of 4,200 kW situated on the shores of Loch Gair into which the water will be discharged. The scheme is estimated to cost £1,300,000.

A White Paper on the scheme has been published (H.M. Stationery Office, 3*d*.).

* * *

ANGLO-FRENCH ATOMIC AGREEMENT

Promoting Peaceful Uses of Atomic Energy

The United Kingdom Atomic Energy Authority and the French Atomic Energy Commission have recently concluded an agreement for the exchange of unclassified information between the two organisations on a range of subjects. The United Kingdom Atomic Energy Authority will furthermore help the French Atomic Energy Commission by giving advice and by supplying experimentai quantities of various materials. The purpose of the agreement is to promote and develop the peaceful uses of atomic energy in the two countries in conformity with the movement for international co-operation in the field of atomic energy on a world-wide scale.

AERO RESEARCH LTD.: 21 YEARS OLD

Synthetic Resin Adhesives

To mark the 21st anniversary of Aero Research Limited, Duxford, Cambridge, a display illustrating their activities was visited on April 20 by H.R.H. The Duke of Edinburgh. It is probable that, to readers of ENGINEERING, Aero Research Limited are best known for their metal-to-metal bonding process, Redux, which is gaining increasing use in the aircraft industry, perhaps most notably in the Comet and Britannia air-liners and in the Fokker Friendship aircraft now nearing completion in Holland. Although the Redux process and the aeronautical applications of synthetic resins are the firm's deepest technical interests, in fact their manufacture of Aerolite urea-formaldehyde hot-setting resins for the furniture, wood-working and boat-building industries, and Araldite epoxy resins for the electrical industries and for glass-cloth laminates, probably accounts for the major part of their commercial activities.

Aero Research Limited, since 1947 part of the Ciba organisation, was originally a free-lance research organisation set up in 1934 by the present managing director, Dr. N. A. de Bruyne, when he was on the staff of the University of Cambridge. At first the firm were engaged in the design and construction of experimental wooden aircraft, and this led, in 1937, to the manufacture of synthetic resin adhesives for wooden aircraft, from whence followed the idea of a glue for metals.

The firm were, it is believed, the first to foresee the weight-saving possibilities of metal honeycomb sandwich structures for stabilising thin load-carrying skins (British Patent 577790, 1938), a principle which has been adopted increasingly during the last few years by the aircraft industry in England, France and the United States. In the present-day Aero Research process for honeycomb sandwich, the thin outer skins are bonded by a film of Redux to the honeycomb metal-foil core.

The Redux process for metal-to-metal bonding was launched in 1942; the de Havilland company were the first to appreciate its potentialities and to apply it in their Hornet. Development work is now proceeding on a high-temperature metal adhesive, Hidux, for high-speed applications where aerodynamic heating effects are becoming apparent, the use of Redux being limited to temperatures below 80 deg. C.

Among the features illustrated in the firm's anniversary display are a series of demonstration units showing how strains occur in glued joints, how wetting and freedom from residual stress are essential to good adhesion, and how radio-frequency and strip-heating can be applied to accelerate the setting of synthetic resin glues. A Tormentor Yacht Station Flying Fifteen glued throughout with Aerolite 300, a propeller spinner of Araldite and glass cloth, a number of electrical components "potted" in Araldite, and various Redux-bonded aircraft components are also exhibited.

★ ★ ★

SCIENCE AND TECHNOLOGY OF GLASS

Research Association Takes Over

Formed under the auspices and with the encouragement of the Department of Scientific and Industrial Research, the British Glass Industry Research Association was registered as a company, limited by guarantee, on October 9, 1954.

The establishment of this new research organisation marked an important step in the scientific and industrial development of the British glass industry, but, unlike other newly-formed research associations, it did not have to inaugurate its investigations; it simply took over the research programme of the Department of Glass Technology of the University of Sheffield and is thus continuing the tradition of research work begun there during the war of 1914-18. This research, in conjunction with the teaching and training of students of glass technology, has been administered by the Glass Delegacy of the University of Sheffield.

It has recently been decided that the British Glass Industry Research Association and the Department of Glass Technology are to be administered separately, although they will share the same University buildings at Elmfield, Northumberland-road, Sheffield, 10. The two departments will be run in close collaboration but their finances and administration will be entirely separate. On the Research Association side, the industry will subscribe a minimum of £20,000 a year which will earn a grant of £10,000 a year from the Department of Scientific and Industrial Research. Moreover, for every complete £100 over £20,000 per annum, subscribed by the industry, the Government grant will be increased also by £100. Thus, there is considerable encouragement for the industry to devote substantial funds for the advancement of its collective research activities.

The bulk of the money required to run the Department of Glass Technology will continue to be provided by the University of Sheffield, but manufacturers have undertaken to maintain their financial support of the Department.

Mr. R. W. Douglas, B.Sc. (Lond.), F.Inst.P., F.S.G.T., a senior member of the research organisation of the General Electric Company, Limited, Wembley, and honorary secretary of the Society of Glass Technology since 1949, has been appointed to succeed Professor H. Moore, in the Chair of Glass Technology. Professor Moore is retiring at the end of the session and Mr. Douglas will taken up his new duties on October 1. Dr. R. G. Newton, D.I.C., hitherto deputy secretary of the International Rubber Research Board and the International Rubber Development Committee, is entering a new field of research as director of the British Glass Industry Research Association. Dr. D. K. Hill has been made assistant director.

★ ★ ★

FLYING GEOPHYSICAL LABORATORY

Three Surveying Systems in Aircraft

A single Canso flying-boat carrying all of the three major types of airborne geophysical equipment has been produced by Aeromagnetic Surveys Limited, 1450 O'Connor-drive, Toronto, and it is claimed that in one survey flight data can be collected that previously required two aircraft making two separate flights. The three types of equipment installed are: an airborne magnetometer, which records variations in the earth's magnetic field, thus aiding geologists in the search for iron, oil, asbestos, titanium and nickel; a scintillation counter, an airborne instrument that gives clues to the presence of uranium in the earth; and an electromagnetic detector, or EM, which can directly locate "sulphide bodies" that may contain copper, lead, zinc or nickel.

A major problem in the development of the flying laboratory was to design an electromagnetic detector that could be used with a metal-skinned aircraft, the only type large enough to lift the half-ton of equipment for all three systems. This problem was solved by mounting a specially-designed compensating device outside the plane. Surveys had previously been carried out with the magnetometer and scintillation counter mounted on the same aircraft, but the incorporation of EM gives much additional information; information from all three instruments is more conveniently comparable because it is all obtained on the same flight line.

The findings of EM and the magnetometer complement each other neatly, since the magnetometer gives a regional picture of geology and structure and indicates magnetic mineral concentrations, while EM indicates sulphide bodies which may or may not be magnetic. Under favourable conditions EM may detect sulphide bodies as much as 300 ft. below the earth's surface.

Letters to the Editor

TECHNICAL STAFF FOR BRITISH RAILWAYS

Salary Ranges

SIR, As another of "the four hundred" mentioned by your correspondent in his letter published on May 6, I can add to the information he has given on the treatment of technical staff on British Railways.

In 1953 the Railway Executive graded the positions of the staff with salaries up to about £1,700 a year. In some of the groups the range between minimum and maximum is only £50, so that the prospect of making steady progress, as was the case prior to nationalisation, is extremely small. The condition was made worse in some instances where men were placed in salary ranges in which the maxima were well below their existing salaries.

The British Transport Commission in its statement on the modernisation of British Railways says it intends to make extensive use of Diesel locomotives, yet it may interest the potential technical staff for railways to learn that the chief draughtsman who designed the B.R. Diesel-electric locomotive exhibited at the Festival of Britain in 1951 was placed, in 1953, in a salary range having a maximum of £868.

By all means let young engineers join the technical staff of British Railways and they may find interesting work, but they will not find any financial attraction.

Yours truly,
P. W. BOLLEN.

22 Manor-road,
Folkestone.
May 11, 1955.

★ ★ ★

NATIONAL WATER SUPPLY

SIR, I submit that a water grid is the rational development required for water supply and not nationalisation. The water grid I propose is of course as a co-function with navigation of the Grand Contour Canal, outlined in ENGINEERING, page 741, vol. 176 (December 11, 1953). This canal follows the outcrop line between the low claylands and the hard-strata uplands (as the old canals often did) and so can maintain a uniform level of 310 ft. above sea level. The waterway of 1,500 square feet cross section could deliver 2,000 cusecs for regional distribution, using suitable means to impel the water. The main flow would be from the hill streams to the water-short areas.

A Grid Commission could carry out the operations and regulate water regionally by the simple process of trading raw water in bulk to the supply authorities, these remaining much as they are now. As free agents they could buy or not buy according to what other supplies they have locally. The water-company form of undertaking is specially suitable for promoting large ground water re-charge schemes, such as the "Costwold Scheme," in association with the Grid.

There is one addendum to the project. Over and above town and industrial supplies the writer is advised by agricultural experts of what ultimately will be an enormous irrigation demand to sustain intensive cultivation. The Suffolk arm of the project would therefore be planned primarily as an agricultural-water supplier to East Anglia. A similar contour branch is not feasible into South-East England; a pipeline it must be, and I suggest lined tunnels in the chalk. Two main lines would then follow the North and South Downs, respectively, siphoning the river gaps, and if designed for a low hydraulic gradient to preserve the head, they would well command most of the country.

Yours faithfully,
J. F. POWNALL.

Linch Hill Farm,
Slough, Bucks.
May 16, 1955.

OPPORTUNITIES FOR SELLING ELECTRICITY

Annual Luncheon of E.D.A.

The saturation point of consumption of electricity was farther away than ever, said Earl Jowitt, P.C., at the Annual Luncheon of the Electrical Development Association on May 10, 1955. Even though the consumption had increased enormously since before the war, there was now, with the notable increase in generating capacity, a wonderful opportunity for the sale of electricity and electrical appliances. Since 1947, three million consumers had been added to those supplied by the Central Electricity Authority, and the units sold per consumer had increased by 60 per cent. There was also a fine opportunity for selling electricity to farmers since the number of farms connected had increased from 78,000 in 1947 to 152,000 in 1954.

In reply to Lord Jowitt, the President of the Electrical Development Association, Sir John Hacking, M.I.E.E., said that the growth of the electrical industry was paralleled by the growth of industry in general and of the oil industry in particular. It was essential that this growth should be maintained and accelerated, both for the good of the electrical industry and for industry in general. There had been a steady increase in the overall efficiency of generation from 20·87 per cent. before vesting date to 23·4 per cent. in March, 1954, but we were still some way behind the American overall average of 28 per cent. Sir John concluded by proposing the toast of The Guests, to which the Hon. L. W. Joynson-Hicks, M.A., M.P., Parliamentary Secretary to the Ministry of Fuel and Power, replied.

At the annual general meeting of the Association, held on the same day, Viscount Chandos, D.S.O., M.C., was appointed President for the year 1955-56, in succession to Sir John Hacking.

* * *

ELECTRICAL ASSOCIATION FOR WOMEN

Progress May Lead to "Regress"

The keynote of the thirtieth annual conference of the Electrical Association for Women, which was held in London on Wednesday, April 27, was progress; and the report for 1954 shows the progress made by and because of the Association since 1924. At the luncheon which followed the business session Lord Citrine pointed out that domestic electrical consumers were now 30 times more numerous than in 1924; this in itself was a tribute to the activities of the Association. Supply had now been carried to the remote recesses of the countryside and all this had been done while keeping prices down to a satisfactory level. He confessed that he was fascinated by the future and looked forward to progress at an accelerated rate. Electricity was no longer a luxury, but was indispensable. To develop it fully emphasis must be laid on increasing the skill of the demonstrators and thus building up an irresistible force of feminine opinion.

Dealing with the future of domestic electricity Mrs. J. L. Stocks recalled that one of the features of the Industrial Revolution was the development of steam power and transport. As a result, production had become concentrated into large units and the specialist was now dominant in most walks of life. This was not altogether an advantage. It was, however, a matter for speculation whether electricity, with the domestic equipment which it had brought in its train, would not reverse this trend; and in the "regress" which would follow there would not be a saving in expense, greater efficiency and a growth of freedom both in the home and elsewhere.

Book Reviews

BREAKDOWNS AND FAILURES: A CENTURY OF ORGANISED INSPECTION

Technical Report of the British Engine Boiler and Electrical Insurance Company, Limited. New Series, Volume II. *British Engine Boiler and Electrical Insurance Company, Limited, 24 Fennel-street, Manchester*, 4. (12*s.* 6*d.*)

A hundred years ago there appeared in the *Manchester Guardian* the following item of news :—

"Explosion of Steam Boilers.—We are glad to find that measures are likely to be adopted for the prevention, as far as possible, of the lamentable accidents which have of late so frequently occurred by the explosion of boilers. We understand that at a meeting of influential gentlemen held yesterday, the desirableness of forming an association for effecting the above object was unanimously approved of, and that the public will shortly be made aquainted with the steps proposed to be taken for securing so great and important an advantage."

The meeting heralded the formation of the Manchester Steam Users Association, the precursor and pioneer of many engine and boiler inspection organisations dedicated to increasing the reliability of engineering installations.

Realising the importance of learning from failures, these organisations have published periodical technical reports dealing with the investigation of boiler explosions, engine breakdowns and other failures, and have thereby performed a service of incalculable value to the progress of engineering. The present report, issued by the British Engine Boiler and Electrical Insurance Company, is the second in the new series, the first of which was published in November, 1952, and marks the centenary of the event noted above. Appropriately, it begins with an historical review of progress in the past century.

During the first half of the Nineteenth Century there was growing public concern over the number of boiler explosions that were taking place. No one could claim to know how many there were, for it was no one's duty to compile statistics, but they occurred with alarming frequency and were often disastrous, boilers literally blowing to pieces, and casualties sometimes running into double figures. The period was one of intense industrial development, and as the demand for higher working pressures was tending to outstrip the ability of engineers to meet it safely, the problem was clearly one that was likely to become worse. Boilers were often poorly designed and built; they were frequently overworked; deterioration in service continued unchecked; feed-water was obtained from any convenient source regardless of quality; and attendants were generally untrained and were sometimes raw youths. An explosion did not call for Government action unless there was loss of life, and even then the investigation did not go beyond a coroner's inquiry. Furthermore, it was widely believed that explosions were fortuitous, arising from influences beyond human control—an attitude that did not encourage investigation.

Such a state of affairs is hardly credible to-day, when public safety is guarded by highly efficient organisations backed by long experience and fortified by legislation. It is therefore a chastening experience to read, in compact form, of the many vicissitudes which have accompanied the transition from the hazardous conditions of a century ago to the comparative safety of to-day. The historical survey, though thorough and detailed, is far from tedious, and will no doubt stand as a valuable source of reliable information. There are numerous illustrations and a statistical appendix.

The book, which is amply illustrated and excellently printed on art paper, also contains a series of 33 reports on failures of a wide variety of types, each of which contains lessons of obvious value to engineers. These reports form, moreover, a useful guide to the technique of investigation, and clearly illustrate the pitfalls which may result from over-facile explanations. Designers may, perhaps, be surprised by the occasional strange behaviour of materials which they have been trained to regard as infallible, but this fuller appreciation of the limitations of such materials can do nothing but good.

The book ends with a paper by Mr. G. A. Cottell, M.Sc., A.I.M., research engineer of the company, on "Fatigue Failures, with Special Reference to Fracture Characteristics." This clearly presented and amply illustrated paper will be of great assistance to engineers in diagnosing the causes and origins of fatigue failures through the interpretation of the surface markings and other features of the fractures. It is also a compact and readable introduction to the complex subject of fatigue in metals.

Technical Mathematics. By HAROLD S. RICE and RAYMOND M. KNIGHT. *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (52*s.*)

The material contained in this text has been used for many years in a preliminary pre-calculus course given by the authors at the Wentworth Institute in Boston to post-secondary students preparing to enter some field of technology. It is at this early stage of mathematical education that it is particularly necessary to make sure that solid foundations have been laid and no gaps left. Moreover, if sufficiently detailed explanations are to be given and no steps omitted a considerable amount of space is needed. Certainly ample space has been taken here for the text occupies some 620 pages.

The topics covered have been grouped into seven "teaching units" under the respective headings: Slide Rule and Review of Arithmetic and Geometry, Basic Algebra, Advanced Algebra and Logarithms, Introduction to Analytical Trigonometry, Numerical Trigonometry of the Right Angle, Oblique Triangles and Applications of Numerical Trigonometry, and Analytical Trigonometry (including Vectors). The attempt to make these units self-contained entails some duplication that might otherwise have been avoided, such as the repetition of the definitions of the trigonometric functions in units 4 and 5, the discussion of interpolation in units 1, 3 and 5. Again, although directions for using the slide rule are given in unit 1, its method of graduation is not explained until unit 3.

An essential ingredient in an elementary course in mathematics is an extensive collection of examples designed partly to develop manipulative dexterity and partly for acquiring facility in translating a problem, stated verbally, into equation form. In this respect the user of this book is well served, for nearly 5,000 examples are included illustrating an exceptionally wide range of practical problems, with answers at the end to every other one. Helpful hints are given for converting formulæ into the shape most convenient for computation and stress is laid on retaining in the final result only the number of significant figures justified by the data, and on checking results by a consideration of special cases as well as by direct substitution.

In the statement on page 91 that "weight equals volume times density," mass should be substituted for weight, and in chapter 8 mention might have been made of the more direct method for evaluating a third-order determinant, sometimes known as the rule of Sarrus.

Apart from some overlapping most of this volume, and all the examples, would be useful in junior mathematics classes at technical colleges in this country.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in later issues of ENGINEERING.

Explosion from a Steam Trap at the Tovil Mill of Messrs. Albert E. Reed and Company, Limited, Maidstone, Kent. Report of a Preliminary Inquiry (No. 3377). *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.*)

The report states that: "The explosion was caused by over-pressure, there being no suitable relief valve in that part of the system which the steam trap served. Furthermore, the relief valve originally fitted to the trap had been rendered inoperative."

Engineering Cybernetics. By H. S. TSIEN. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6·50 dols.); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (46*s.* 6*d.*)

Engineering cybernetics is the science of control as applied to electrical and mechanical systems. This book treats the science theoretically, and aims to organise the design principles used in engineering cybernetics practice into a discipline to exhibit the similarities between different engineering applications. A book for the research worker or student rather than the practical man, demanding the understanding of mathematics normally possessed by the research engineer.

Electro-Technology: Basic Theory and Circuit Calculations for Electrical Engineers. By M. G. SAY. Second edition. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.*2. (10*s.* 6*d.*)

This book, which was first published as *Electro-Technology and Calculations* in 1947, aims to give in compact form a guide to the handling of circuit problems for two-terminal and four-terminal cases and for balanced and unbalanced three-phase cases. It covers most of the primary circuit problems for both steady and transient states. A feature is the collection of the network theorems, which are of such great importance in rendering circuits with internal complication more tractable. As not all every-day problems can be usefully dealt with by circuits alone an introductory exposition of conduction and of magnetic and electric field effects is given. The electro-technical basis of phenomena which are important in light and heavy electrical engineering are presented briefly. But specialised technologies such as machinery, switchgear and electronics are not dealt with.

Current Ratings for Paper-Insulated Cables to B.S. 480 : 1954 and Varnished-Cambric-Insulated Cables to B.S. 608 : 1955. Report No. F/T183. *The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.* (5*s.*)

This report covers the revised edition of British standard specification No. 480 : 1954, including aluminium-sheathed cables. It takes account of the higher operating temperatures for certain cables which are now permissible by agreement with the Cable Makers Association. Reference to this question, in connection particularly with soil resistivities, was made in detail on page 490 of ENGINEERING for April 22, 1955.

Electrical Characteristics of Overhead Lines. By S. BUTTERWORTH. Report No. 0/T4. (42*s.*) **Handbook on Electrical Characteristics of Overhead Lines.** Report No. 0/T4A. (15*s.*) *The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.*

The first publication gives a complete account of those characteristics of overhead electrical transmission lines which affect the currents and voltage during steady-state and fault conditions. The basic constants normally used for the calculation of power flow or voltage drop are defined, and the determination of the effective characteristics for balanced three-phase operation with simple and multiple conductors is discussed, as is the determination of zero-sequence characteristics with and without earth wires. Other subjects covered are corona, current-carrying capacity and power transmission, the last under the headings of short and long lines and transformer impedance. The second report covers the same subjects in abridged form.

Interim Report on the Shell Moulding Process. By J. L. RICE. Miscellaneous Publication No. 468. *The Association of Bronze and Brass Founders,* 69 *Harborne-road, Edgbaston, Birmingham,* 15. (5*s.*)

Mr. Rice is a member of the research staff of the British Non-Ferrous Metals Research Association and his report has been made after spending some three months in consultation with makers of shell-moulding equipment, suppliers of resins and users of the process. It is an objective survey of shell moulding as it has developed up till the present time and is intended to give the foundryman some conception of the advantages and disadvantages of the process and of the economic factors involved.

Iron Moulding for Apprentices. By FRANCIS D. ROPER. *Ernest Benn, Limited, Bouverie House, Fleet-street, London, E.C.*4. (15*s.*)

The aim of the author is to deal with the fundamental principles of the craft of moulding from the practical angle. He describes venting and ramming, joints, open sand moulds, loam moulding, cored work, gating methods, etc. A brief history of the craft of moulding is included.

Machining Aluminium. Information Bulletin No. 7. *The Aluminium Development Association,* 33 *Grosvenor-street, London, W.*1. (2*s.*)

A revision of the A.D.A. Information Bulletin No. 7, on the machining of aluminium, first published in May, 1944, has now been issued. Data on the machining of cast alloys have been added and the scope of the publication now covers workshop practice in the extended range of industries which have adopted aluminium since the work first appeared. Information is given on machine-tool materials, cutting compounds and lubricants, and tool design for turning, boring, parting and other machining operations.

Conference on Open-Hearth Flames and Output. *West of Scotland Iron and Steel Institute,* 39 *Elmbank-crescent, Glasgow, C.*2. (17*s.* 6*d.*)

The five papers presented at the Conference on Open-Hearth Flames and Output, held by the West of Scotland Iron and Steel Institute on September 10, 1954, have now been published, together with the ensuing discussion and the authors' replies. The authors of the papers are Professor M. W. Thring, Dr. G. W. C. Allan, Mr. J. A. Leys, Mr. E. J. Burton, and Mr. W. B. Wright. The report runs to 96 pages and contains upwards of 30 line and half-tone illustrations and a bibliography.

Road Research, 1954. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s.*)

Road Research, 1954, is the seventh of the post-war annual reports dealing with the work of the Road Research Laboratory. The Laboratory is responsible for research on (1) road safety and the flow of road traffic; (2) road-making materials and machinery, and the methods of road construction. The report summarises the progress made at the Laboratory on these two topics and related subjects. Particular investigations mentioned include: traffic density and the case for motorways; the need for improved toughened-glass windows; vehicle skidding, its cause and contributing factors; and other accident statistics. Work has been continued into basic studies of the road structure and reference is made to: effects of soil moisture on sub-grade strength; soil compaction plant; the use of rubber in bituminous surfaces; and colouring of road surfaces.

Foundation Engineering: A Survey of Modern Practice in the Solution of Foundation Problems of All Kinds. By ROLT HAMMOND. *Odhams Press, Limited, Long Acre, London, W.C.*2. (21*s.*)

Beginning with two chapters on soil mechanics and site exploration, the book has a number of chapters on specific types of foundation problems: foundations for houses, buildings, bridges, maritime structures and for heavy machinery subject to vibrations. Examples chosen for description have been taken from the author's experience and from other sources. Each case, selected to illustrate a particular type of problem, is reported in detail: methods, measurements and the results achieved are quoted so that students and experienced engineers alike can assess problems that come within their consideration on the basis of past experience. Each chapter is concluded by a bibliography listing books, papers to the professional institutions and articles in the technical Press.

Mechanical and Electrical Equipment for Buildings. By CHARLES MERRICK GAY, CHARLES DE VAN FAWCETT and WILLIAM J. MCGUINNESS. Third edition. *John Wiley and Sons, Incorporated,* 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (8·50 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (68*s.*)

This volume covers the theory and practice of the important types of mechanical and electrical equipment for buildings, including acoustical materials and supporting media. The main sections are water supply, sanitation, heating, air-conditioning, electrical equipment, and acoustics. The book demands no advanced mathematical knowledge, and is written as much for the builder and architect as for the engineer.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Steel Structures. UNITED STEEL STRUCTURAL CO., LTD., Frodingham Works, Scunthorpe, Lincs. Buildings for offices, hospitals, factories, garages and grandstands; gas plants, chimneys and elevators, tubing and "Castella" beams, bridges and cranes, cycle stands and bus shelters. Contributions made by the company to construction of many structures during recent years. Picture album showing work during erection and as finally completed.

Moisture Adsorbers. BIRLEC LIMITED, Tyburn Road, Erdington, Birmingham, 24. Details of the Birlec "Lectrodryer," which is designed to remove water vapour from air, other gases and certain organic liquids. The operating principle, adsorption by activated alumina, is described. Several installations are illustrated, including the two-unit type for continuous operation. The standard sizes listed are up to 1,000 cubic ft. per minute; larger sizes and units for high pressures are also mentioned. Re-activation is by steam or electric heating. Illustrated folder.

Drilling and Hacksawing. W. J. MEDDINGS LTD., 16 Berkeley-street, London, W.1. "Pacera" range of drilling machines of the bench and pillar type, with capacities up to 1½ in. diameter in mild steel. Details are given of multiple-head machines, multi-spindle heads, extension arms and air/hydraulic feeds. Auxiliary equipment including vices, suds pumps and drill-guards are also described, as are special-purpose adaptations of drilling heads. Bench jig-saws and power hacksaws are also detailed. Illustrated catalogue.

Relays and Control Apparatus. LONDEX LTD., 207 Anerley-road, London, S.E.20. Synchronous process timer, time range 1 sec. to 60 min. or ½ sec. to 15 min.; delay relay type LF/T1, maximum delay period 5 secs., contact rating 4 amperes at 250 volts a.c.; coaxial relays types SCX and GCX; automatic earth leakage equipment type E.L.U.; measuring relay type HS/C. Five illustrated leaflets.

Steel Shutterwork. BLAW KNOX, LTD., 90-94 Brompton-road, London, S.W.3. Steel shuttering is illustrated for tunnels and aqueducts (for road and railway tunnels, subways, circular and arched conduits and box culverts); dams; caissons and shafts; walls; piers and columns; bridges and viaducts. Notes are given on data required when making inquiries and on practical designing. Illustrated catalogue.

Alternating Current Industrial Electric Motors. LANCASHIRE DYNAMO AND CRYPTO LTD., St. Stephen's House, Victoria Embankment, London, S.W.1. Abridged specification of protected, screen protected, drip-proof, pipe-ventilated, totally-enclosed and fan-cooled alternating-current motors up to 250 h.p. Frame sizes, dimensions, speeds and outputs. Illustrated pamphlet. Also price list, including details of motors in stock.

Electro-Precipitation. SIMON-CARVES LTD., Cheadle Heath, Stockport, Cheshire. Precipitation of dust by electrostatic methods, development, advantages, principles and types of apparatus; construction plant arrangement, electrical equipment, applications of electro-precipitation; generation and characteristics of dust. Illustrated book entitled "High-efficiency Electro-Precipitation."

Electrical Insulating Materials. MIDLAND SILICONES, LTD., 19 Upper Brook-street, London, W.1. Siliconic flexible and rigid insulation; silastomer flexible insulation; silicone-insulated cable and wire, silicone adhesives, silicone impregnating varnish; description and some technical data; representative list of suppliers. One leaflet, one illustrated booklet.

Vacuum and Pressure Impregnation. BLICKVAC ENGINEERING LTD., 96-100 Aldersgate-street, London, E.C.1. Impregnation in electrical and other applications; high vacuum pump, control panel, autoclaves and storage chambers. Illustrated pamphlet with dimensions and technical data.

Outdoor Lighting Equipment. THE BENJAMIN ELECTRIC LTD., Tottenham, London, N.17. Enclosed and open floodlights, race-track fittings, road lighting reflectors, dispersive, distributing and angle reflectors; parts, accessories and instruments. Illustrated book.

Site Exploration. SIMON CARVES, LTD., Cheadle Heath, Stockport. Site exploration and soil mechanics relevant to foundations. Services provided by the company and facilities at their disposal. Illustrated leaflet.

Institution of Naval Architects Spring Meeting (*continued from page* 593)

SEA TRIALS OF A MOTOR CARGO LINER

The fifth paper in the programme for the Spring Meeting of the Institution of Naval Architects was presented at the evening session on Tuesday, April 5, at a meeting held jointly with the Institute of Marine Engineers. The author was Professor G. Aertssen and the paper dealt with "Sea Trials on a 9,500 Tons Deadweight Motor Cargo Liner." The chairman was Sir Stanley V. Goodall, K.C.B.

SEA TRIALS OF THE MOTORSHIP LUBUMBASHI

The paper described the second part of a programme of sea trials organised by the Centre Belge de Recherches Navales, the vessel concerned being the motorship Lubumbashi. She had been equipped for the purpose with a torsionmeter, thrustmeter, Pitometer log, anemometer and wind vane. Records were taken, under varying conditions of draught, fouling and weather, of the speed, power, fuel consumption, thrust, revolutions, etc., and of the weather conditions and the waves encountered. To establish the ship-model correlation, a model of the ship was made and was tested at the National Physical Laboratory, Teddington, under the superintendence of Dr. J. F. Allan. Two trials were made with the ship on the measured mile at Polperro, one in the ballast condition, as part of the official trials of the ship, and the other in the loaded condition, at the beginning of her maiden voyage. The main engine, which developed 6,000 brake horse-power, was designed to run on heavy fuel oil and usually did so, except when entering and leaving port and on the first voyage, when Diesel oil was used.

DISCUSSION: ACCURACY OF MEASUREMENTS

Dr. J. F. Allan, who opened the discussion, said that the paper had many points of contact with the work of the British Shipbuilding Research Association and the National Physical Laboratory. On the question of accuracy, the measurement of the speed through the water was dependent on the Pitometer log, which was calibrated on the measured mile trials. So far as it had been calibrated on the measured mile in calm water it was probably very reliable; but did the author form any impression during the trials as to the loss of accuracy in the log in pitching conditions? He thought that the accuracies stated in the paper tended to be on the optimistic side, even considering the fact that the torsionmeter was calibrated on the shaft. The roughness measurements presented features of some difficulty because the data were not entirely complete as between the Lucy Ashton and the Lubumbashi, as the actual measurements of physical roughness were not always made under the same conditions. Taking the comparable increases in the roughness of the two vessels after six months, the increase in resistance on the Lucy Ashton was much greater than that on the Lubumbashi, which, he suggested, was a point of some importance. There was a growth of barnacles on the Lucy Ashton, which various speakers on Dr. Livingston Smith's paper thought might be responsible for the large increase in resistance; against that there were the rough blisters mentioned by Professor Aertssen.

A further point worth mentioning was the amount of scum on a ship. When a model had been in the tank for some weeks a scum developed which was smooth to the touch, but there was a marked increase in the resistance; a ship docked after a long period at sea frequently had a similar slimy fouling, which could not be measured with any kind of roughness meter. The determination of shaft losses was an extrapolation and, on the face of it, looked fairly plausible; but unless the operation was carried out at very low revolutions, too much reliance should not be placed on that method of determining the friction of the tailshaft or of the transmission line.

RELATION BETWEEN POWER AND WEATHER

The analyses of the weather results were extremely interesting, and, though the details might be criticised, the broad picture could not be denied. The most interesting point, from his point of view, was the very rapid increase in the power required to maintain a given speed when the weather factor exceeded a certain amount. In general, there was a tendency to assume a rather low weather factor; his own inclination was to allow for a weather factor rather larger than was generally accepted. Up to about a Beaufort figure of 4 or 5 there was a fairly moderate increase of power, but after that a very spectacular increase. Taking a figure of 25 per cent. or so at 4 or 5 on the Beaufort scale for fouling, an overall figure of 35 per cent. was a very safe one to work with; but that was much higher than was generally accepted.

For the ship-model correlation, the general picture was fairly satisfactory; but, on a more detailed consideration, it was not quite so satisfactory as it looked at first sight. The paper showed a disagreement between the predicted results and the measured results derived from shaft horse-power of from 0·92 to 0·95 in the loaded condition and from 0·975 to 1·027 in the ballast condition. Those compared reasonably well with the standard N.P.L. practice of using a coefficient of the order of unity for that type of shell construction; in other words, the ship had performed more or less as he would have expected.

Mr. A. W. Davis was interested particularly in the relation between the increase of power and the idiosyncrasies of the weather. It was more or less the practice for vessels on the North Atlantic to allow an increase of power of about 30 per cent. for maintaining speed under average weather conditions and with an average dirty hull; from the author's figures it would seem that that was not an over-estimate of the requirements. In the early part of the paper reference was made to the relative effects of running with Diesel oil and with so-called heavy fuel oil. It would be interesting to have particulars of the heavy oil actually used. It could be most misleading merely to record the effects on an engine of a particular heavy fuel, because of the enormous variation that could exist between one fuel and another. It would also be interesting to know whether there was any change made in the spread between using the Diesel fuel and the heavy fuel. The author's remarks on hull roughness were also interesting. The former naval architect of Mr. Davis's firm used to allow an increase of power of 2 per cent. per day out of dry dock.

SHIP-MODEL CORRELATION

Professor A. M. Robb expressed the view that ships should not be rushed too hastily out of dry dock, but should be allowed to stay there for an extra day to enable the paint to harden properly; a practice which saved far more than was lost by leaving them in dry dock for the extra day. With regard to ship-model correlation, Dr. Allan had omitted one point about the model propeller in open water. It happened very conveniently that if K_T was plotted against K_Q the result was very nearly a straight line, certainly over the working range for the model; for the ship, however, the spots were all above the line on the graph, with quite a considerable gap between. He did not know why that was so, the data being very limited; but until that part of the correlation problem was solved, they could not say that they had really tackled the problem.

Mr. H. J. S. Canham, quoting the reference in the paper to the accuracy of the thrust measurements, expressed surprise that the author considered the accuracy of measurement on the loaded trial to be greater than in the ballast trial, since only the ahead type of Michell thrustmeter was fitted. A correction could be applied to take into account the weight of the shaft and he could not see, therefore, why there should be any less accuracy in the ballast trial. He was pleased to note that the torsionmeter had been calibrated on the shaft on this occasion. That had prompted him to compare the figures for accuracy in Professor Aertssen's paper of two years ago with those in the present paper. In the present paper it was stated, for instance, that the torque (the shaft being calibrated in the shop) was measured to an accuracy within 2 per cent. in smooth water. Was that $\pm$ 1 per cent. or $\pm$ 2 per cent.? [Professor Aertssen: It is $\pm$ 2 per cent.] The point was that in the previous paper Professor Aertssen quoted 3 per cent. for an uncalibrated shaft. At the B.S.R.A. in connection with some recent results, they considered that a figure of $\pm$ 3 per cent. should be allowed. As, in the present case, the shaft had been calibrated, he thought it would be agreed that he should get the torque measurements accurate to within $\pm$ 2 per cent. The B.S.R.A. had carried out tests on a thrustmeter, and concluded that an accuracy within $\pm$ 2 per cent. was achieved. The present paper gave 4 per cent. in smooth water and 5 per cent. in rough water. He did not question the rough-water figure, because all sorts of things happened in rough water, but he would like to know why the author considered that, in smooth water, the errors were within $\pm$ 4 per cent.

ROUGHNESS MEASUREMENT AT TIME OF TRIAL

The important thing in the measurement of hull roughness was to measure that roughness at the time the ship was on trial, particularly during the measured mile trial. In almost every case, with one notable exception, the ships had been coated with an anti-fouling paint before the trials, and the period between the painting and the trials varied. The exception was the Lucy Ashton, which had no anti-fouling paint. There was a marked difference between an anti-fouling paint and an anti-corrosion paint; the former was essentially one which dissolved or leached into water, and, from his own experience, he could say that those paints did get very soft indeed. Therefore, it seemed, there was some action between the paint and the water as soon as the ship was undocked. If so, the hope of knowing what the surface was like at the time of trial was rather remote, even if the interval between undocking and the trials was cut down. Attempts had been made to explore the nature of the roughness of paint surfaces on test panels; but he doubted whether the results obtained really gave much indication of the condition on the ship. He thought that it would be better to consider the grosser form of roughness usually encountered on the painted hull. Professor Aertssen had used a pneumatic feeler. The B.S.R.A. had developed a mechanical gauge which gave a record of the profile of the shell surface. It had the advantage that a very great number of records could be taken quickly. A disadvantage of the pneumatic feeler was that it gave no record at any time of what the surface looked like. So far as the investigation on the Lubumbashi was concerned, he felt that little reliance could be placed on the pneumatic feeler readings, except that apparently they did register about the increase of roughness that would be expected over six months. It would be better to rely on the figures obtained from the boundary layer traverses, from which were deduced the equivalent sand roughnesses of the hull. It was interesting to note the astonishing

increase over six months and that it then accounted for about 9 per cent. of the total power. He could not agree with the author that the figures for the sand roughness correlated well with the measurements of the roughness of the hull established by the pneumatic method, though, admittedly, account must be taken of rust. The method of estimating the shaft loss, he considered, proved no more than that the loss lay within the limits of ± 5 per cent.; probably as accurate results could have been obtained by taking the thrust deduction at measured speed.

With regard to the tank test report, he was rather surprised that the comparison of the ship revolutions and the model revolutions at the same power absorption differed from the loaded to the ballast condition. In the loaded trials the figure was less than 1; it gave a factor, generally speaking, of 0·99, whereas in the ballast trials the figure was almost invariably over 1, except at top speed. He did not see why there should be that difference between the trial results. A paper read before the Institution in 1954 gave results for 37 ships. Of those, five gave an r.p.m. figure equivalent to less than 1; in other words, in almost every case the ship r.p.m. was greater than the r.p.m. predicted from the model—and he thought that Dr. Allan would agree that in two cases out of the five they would probably revise their opinion shortly. He wondered, therefore, whether the author's results were right.

THE ENGINE IN SHIP-MODEL CORRELATION

Professor E. V. Telfer said that, in dealing with ship-model correlation he had found that, when the engine intervened, it must be eliminated from the ship and considered as an engine only; so that the first step in correlation was to take the engine results purely as engine results and preferably to adopt the following type of presentation. With ordinates of mean indicated pressure and a base of mean effective pressure, plot all the results available for the particular engine, whether the tests were carried out in the ship in the loaded or the ballast condition, or on the test bed. Then take the particular value of mean effective pressure at a given point and draw it down from the total m.i.p., so obtaining a series of lines which possibly would show a gradually increasing total of static and running friction. That type of diagram should be made not only for the ship in question, but for all the engines available, so developing a generic type of diagram. That kind of statistical analysis was much more reliable than any single set of information, and should be the first guide in attempting the bolder step of ship-model correlation. The next step was to analyse the trials, paying particular attention to the results at fairly low revolutions.

In connection with the presentation of speed losses, he suggested that it would be far better to present these in terms of the square of the wind velocity, which was most probably the correct linear cause of the speed loss. If Professor Aertssen could convert his diagram to the base of the velocity squared, his speed losses and power losses would become nearly linear and he would be able to see the continuity of loss far better. The steep rise in his curve in going from Force 4 to Force 6, for example, was rather striking; that steepness was entirely due to the Beaufort number not being really associated with the losses themselves, and he suggested that it would be necessary to go back to the wind velocity in order to get a true correlation.

Mr. J. Foster Petree asked what was the diameter of the calibrated shaft and what method was used in calibrating it. He had had some experience of calibrating torsionmeters on their shafts, though only the optical type and not the electrical, and only with shafts of less than 12 in. diameter. That was sufficiently difficult; but the shaft in the Lubumbashi was obviously larger, and it seemed that, unless there had been a great advance in the technique, it was quite possible that there might be a zero error of 1 or 2 per cent. in the calibration itself.

Mr. H. Lackenby observed that Dr. Allan had raised the question of the effect of scum, as distinct from barnacles, grasses, etc., on resistance. Some data on that had been obtained during the Lucy Ashton trials. The ship was tied to a buoy for 40 days and there was a slight greasy scum on the surface. The resistance was measured in that state, and was found to have increased by 3 or 4 per cent. over and above that measured in the previous condition, which corresponded to about 5 per cent. on the skin friction.

EFFECT OF SIZE ON WEATHER-FACTOR

Mr. John Brown asked whether Professor Aertssen would agree that, in the analysis of the effect of weather on the performance, the size of the ship should also be a factor. A previous speaker had referred to a possible 30 per cent. increase of power as the average weather effect on the North Atlantic. If there was a size effect, on the bigger ships the loss would be less than that; even in the case of ships of moderate size, he thought that the owners accepted a lower percentage than 30 as the allowance for weather. Mr. Canham had spoken about tolerances in measurements. Mr. Brown had recently seen some similar measurements made and was surprised at the variation in the thrust measurements, even in a measured-mile run. Was the author's 5 per cent. " plus or minus? "

Commander L. A. Rupp, U.S.N., referring to corrections to thrustmeter readings, questioned the statement that a two-way thrustmeter would give greater accuracy than a one-way meter. He also asked whether the correction for the static head of the water due to the cross section of the shafting in way of the stern tube was considered. If it were not considered, that might explain some of the discrepancies in the information relating to the ballast condition and the loaded condition. Several speakers had referred to the association of increased power with the Beaufort wind force. Wind had various effects, and they depended on how much of the area of the ship was above the water. The wind also affected the condition of the sea. The still air effect was considered by Professor Telfer, and perhaps his method of plotting it would give the correct answer, but the rough-water effect certainly would not follow any such law. It was directly dependent on the relation between the length of the wave which the ship encountered and the length of the ship, becoming much greater as the length of the ship fell from near equality with the wave length. Therefore he questioned very much the accuracy of using any wind factor in such an analysis.

AUTHOR'S REPLY

Professor Aertssen, in a brief reply to the discussion, did not agree that he had been too optimistic in his statement of the accuracy of measurements; to claim an accuracy of 2 per cent. for torsion and 4 per cent. for thrust was, he thought, on the safe side. Dr. Allan had expressed doubt about the extrapolation diagram for calculating the shaft losses. It might have been better to have taken measurements at lower speeds, but at low speeds it was very difficult to get a steady output from the engines and to obtain constant readings, therefore they did not take measurements at very low speeds during the measured mile trials. In reply to Mr. Davis: heavy fuels of all kinds were mentioned in Table X of the paper, the Redwood viscosity at 100 deg. F. varying from 1,239 to 3,472 seconds, i.e., a variation of more than 2,000 seconds. Those were the fuels normally burned under boilers. The characteristics of the fuels burned in the Tervaete were about the same. Mr. Canham had remarked on the statement that the accuracy of thrust measurements was much better for the loaded condition than for the ballast condition. The reason was that, for the ballast state, a substantial correction had to be applied to take account of the weight component. Professor Aertssen added that he would make a more detailed reply to the discussion in writing.

(*To be continued*)

Iron and Steel Institute Annual General Meeting (*continued from page* 591)

GAS TURBO-BLOWER FOR BLAST FURNACES

COMBINED BLOWING AND BLAST-HEATING SCHEME

Continuing our report of the annual general meeting of the Iron and Steel Institute, held in London on April 27 and 28, we now deal with the proceedings which followed the delivery of the presidential address on the morning of the first day.

The first paper considered was by Mr. C. E. Sayer, a technical director of McLellan and Partners, and was entitled " The Gas-Turbo-Driven Blower for Blast-Furnace Service." Mr. Sayer said that, since the war, much thought had been devoted to the application of the gas turbine to the driving of blast-furnace blowers. The obvious and ideal fuel for any gas-turbo-blower was blast-furnace gas in the clean condition as it was now normally delivered from the gas-cleaning plant. Provision for burning an alternative fuel to provide for failures of blast-furnace gas supply would generally be necessary. In most cases, oil would be the most likely alternative. It was claimed by experienced makers of gas-turbine plant that, provided that the turbine-inlet temperature were not raised above 650 deg. C. (about 1,200 deg. F.), the heavy fuel oil, used almost universally in steelworks for firing furnaces, could be employed without fear of trouble.

As a straight prime mover for driving a blast-furnace blower, the gas turbine was likely to have an advantage in higher thermal efficiency over steam plant. Whatever this difference in thermal efficiency might be, however, another most important opportunity was open to the gas-turbo-blower on account of the large quantity of heat needed to raise the temperature of the blast air, and the scope thereby offered for extracting this heat from the gas-turbine cycle.

The combined gas-turbine blowing and blast-heating scheme had been the subject of much thought but, so far, no attempt had been made to put it into practice. One reason might be that to secure the full saving it was necessary to heat the blast air wholly by heat extracted from the gas-turbine cycle. Blast-furnace managers naturally hesitated to discard their Cowper stoves in favour of some new and untried method of achieving the same result. A second factor was that full heating of the blast without stoves necessitated the inclusion, in the gas-turbine cycle, of a heat exchanger to work at temperatures in excess of the maximum blast temperature called for, which was itself continually tending to rise. Another reason for the gas-turbo-blower and blast-heating combination's being still in the discussion stage was the view that it must wait until a straight gas-turbo-blower had been installed and tried out.

SAVING WATER

Mr. W. F. Cartwright, who opened the discussion, said that the modern stove was very efficient and reliable, and a fairly good prize

would have to be offered to tempt the blast-furnace operator away from this present satisfactory state of affairs. The prize seemed to be mainly in the direction of saving water, which was a bugbear of many inland steelworks and even of works on the coast where there was a fresh-water problem. Consequently, he would have liked the author to have given a little more comparative information concerning the possible efficiency of a " brand-new " steam plant, with its possibility of high blast heats, and that of the heat exchanger with its obvious difficulties of reliability and the like.

Mr. F. Kennedy thought that in the comparative balances in the paper the author had unduly favoured his gas turbine by not making his comparison against a steam blowing plant running under the best operating conditions of high steam temperature, superheat, and that type of arrangement which would give high efficiency.

There was also another fundamental point which must be borne in mind in these comparisons between the gas-turbine and the steam set. The major objective was the saving of heat units and higher efficiency in the utilisation of blast-furnace gas. This was a complicated problem which was really related to the distribution of the blast-furnace gas—that the demands and the rate of production of the gas did not coincide. There must be some unit which acted as a buffer to take these fluctuations, and most practical operators would agree that the ideal buffer was a boiler plant. A boiler plant could be designed in such a manner that there was very little falling-off in efficiency if it were switched over to alternative fuels; and this question of possible alternative fuels did come very much into the comparison of efficiencies because it was the economic cost that had to be considered. If the gas turbine were used as the buffer, the only possible fuel, apparently, was oil, so that the comparatively slight gain in thermal efficiency from the use of the gas turbine could easily be offset by the additional cost of the oil used as an alternative fuel, as compared with coal or coke breeze which, in many cases, was being used very successfully.

Furthermore, the blast-furnace ancillaries, stoves and blowers must be capable of responding to whatever demands the blast-furnace operators put on them. It was necessary to be able to control blast temperature and to vary it fairly quickly, and the author apparently, had not dealt with the question of how he would meet sudden demands for increased blast temperature which might coincide also with quite marked variations in the blast requirements, either in volume or in pressure.

In the matter of giving the operator the maximum flexibility, however, he agreed with the author's contention that, for ease of control, there were very strong arguments for having a separate compressor and blower, so that the furnace requirements were isolated and more easily controlled.

COMBINED BLOWER-GENERATOR SYSTEM

Mr. P. Boël said that a blast-furnace operator demanded a blower that was capable of producing a high volume of air at a high pressure, but his normal operating point would be for a high volume of air at a lower pressure, and therefore the blower would be operating, nearly always, at a point 15 per cent. or 20 per cent. below the maximum point. For an engine such as a blast-furnace blower that worked all the year round, a slight decrease in efficiency represented a considerable outlay at the end of the year, and therefore the blower and the whole machine must work at maximum efficiency at a point about 10 to 15 per cent. below its maximum power. When a gas turbine was slowed down its efficiency declined markedly. To solve this difficulty a combined system had been designed for a steelworks in Belgium. This consisted of a constant-speed gas turbine having, on one side, a blower and, on the other side, an electric generator. The blower took about 60 per cent. of the power of the gas turbine and, in that way, the sum of the electric power generated and the blower volume generated remained constant, and when the operator turned down the blower, he increased the electrical efficiency. It was thus possible to have a gas turbine working at constant speed and at maximum efficiency.

Mr. G. C. R. Mathieson said that, while it was the aim of the company which he represented (Power Jets, Limited), to foster enthusiasm for the gas turbine, it was also their duty to protect it from too much enthusiasm.

His first point was one on comparative efficiency. Gas-turbine shaft efficiency was not likely to be greater than that of the steam plant. At present they were tending to restrict maximum temperature to 650 deg. C. and so the efficiency was not likely to be much in excess of 22·5 per cent., unless the cost of the gas turbine were increased by high pressure ratio or costly heat-exchange apparatus of high effectiveness. Steam plant at 600 lb. per square inch and 700 deg. F. should give a shaft efficiency of 22·5 per cent., and at 850 deg. F. an efficiency nearer 26·5 per cent. Pressures and temperatures were going up on new designs of steam plant, and so with temperatures going up on gas-turbine plant the efficiencies should hold about level.

Since, however, the duty required in the blast-furnace plant was one of both pressure and temperature increase, the effective efficiency of the gas turbine, in pressure plus heat output, was much greater than its pure shaft efficiency. In the combined heating and blowing cycle, quite a fair proportion of the heating of the blast air took place in the heat exchanger at the gas-turbine exhaust, and so the effective efficiency based on shaft output and heating was around the 50 per cent. mark (54·5 per cent. according to his calculations) as opposed to the 23·5 per cent. based solely on shaft output (27·4 according to his calculations). The same stratagem was not possible with the steam plant, as the temperature at the outlet from the boiler or the turbine was not high enough for effective heat transfer.

The incorporation of the air heater in the circuit, so that use of the stack losses was made in the turbine, was a further feature which improved the efficiency of the cycle.

METALLIC AIR HEATER

He then considered possible savings in capital costs. Investigations had shown that it was perfectly practicable to construct an air heater to heat the blast air to 750 deg. C. (1,380 deg. F.) using existing materials at a cost of about 12*s.* per cub. ft./minute as opposed to a cost of about £3 10*s.* per cub. ft./minute for stoves, or £1 10*s.* per kilowatt heat output as opposed to about £9 per kilowatt heat output; even in spite of having to use expensive high-temperature materials at the hot end. There was thus very great scope for capital saving by using metallic heaters in place of the brick types at present employed. It was certainly sufficiently attractive to encourage full-scale experiment.

The other important capital item was the blowing set proper, and here it was difficult to say with any conviction that the gas-turbine plant was cheaper than the steam plant, namely, for blowing only. Obviously, considerable effort must go into cheapening the gas-turbo-compressor set.

Mr. C. Ungoed said that one thing that seemed to worry the author in the combination of the cycle heat exchanger and the gas-turbine was the cycle heat exchanger. Throughout the paper the author had referred to it as recuperative. Had he considered using a rotary regenerator for this piece of apparatus, as it seemed to have greater possibilities in space saving and, if made of ceramic material, would probably have better characteristics in so far as being self-cleaning was concerned?

The author's comparison of steam and gas-turbine cycle efficiencies rather tended to favour the gas-turbine cycle. It must be appreciated that the combination of the cycle heat exchanger and the gas turbine was really an expedient to get over the whole problem of this excessive waste-gas loss from the gas turbine. Similar expedients on the steam cycle, such as back-pressure turbines, could bring up the efficiency of that cycle to approximately 60 or 70 per cent., which, if combined with an independent rotary pre-heater, independently fired, could give an efficiency higher than the 71 per cent. forecast by the author.

Mr. D.M. Smith said that the point had been arised as to whether it was possible to make use of the heat in the gas-turbine exhaust in combination with stove heating as compared with the recovery from a metallic recuperator. So far as the mechanical design of the plant was concerned, the author had made a good case from a performance point of view for the single-line plant at variable speed with separate axial flow blower. In his (the speaker's) opinion there was a good case also for a plant of that type from a mechanical design point of view, because the speeds of the various components fitted in well with one another and they also fitted in, at least as far as the gas-turbine plant was concerned, with gas-turbine plant which might be designed for other applications. In these respects the plant described by the author had advantages both over the tapped regenerative scheme, on the one hand, and over a gas-turbine plant driving a centrifugal blower, on the other hand.

Mr. F. C. Evans said that, apparently, the successful development of a gas-turbine blower for blast furnaces depended on the development of a suitable heat exchanger. The next speaker, Mr. T. P. Everett endorsed the author's views that the time had now come for the iron and steel industry to take the plunge and use the gas-turbine for blast-furnace blowing. At least one steelworks in this country was installing a unit for power generation, and whether the next unit should be for combined power generation and blast-furnace blowing or for blast-furnace blowing alone was something about which he did not feel competent to give advice.

He agreed with the author that the single-shaft unit was the right one; while, in the two-shaft arrangement, there would be, undoubtedly, quite considerable advantages from a part-load operation point of view, the capital cost would be increased, so that the scheme would become quite unattractive.

The heat exchanger, as other speakers had pointed out, would produce design problems which he did not think were yet solved, but it would be of great assistance to the heat-exchanger designers if the author could give them the pressure drops on which he had based his efficiencies, because the pressure drop was the basis of design of such heat exchangers.

AUTHOR'S REPLY

Mr. C. E. Sayer, in reply to the discussion, said that a number of speakers had suggested that he had unduly favoured the gas-turbine plant. He agreed that for a modern steam plant on a large scale and using the highest temperatures, a thermal efficiency of 90·5 per cent. was too low, but his idea had been to take a figure that was representative of the average plant, in many of which the size of units was not so large and would not take with efficiency such high steam conditions as one would use for larger units.

Mr. Kennedy had rather suggested that oil was not very generally used for firing steam-boiler plants in steelworks. He (the author) considered that it was a very general alternative fuel, and from that point of view there would not be very much difference in that respect between the gas turbine and the steam plant.

As regards the relative merits of axial and centrifugal blowers, he did not intend to embark on that subject at all. If he had attempted to cover all the aspects of the question—and in this respect he instanced the question of water saving, mentioned by Mr. Cartwright—the paper would have become too long. The question of water saving was, of course, most important. On the question of the type of blower, as he had pointed out in the paper, the power characteristic of the

two types was so much the same that it really did not affect the gas-turbine diagram whether one was thinking of a centrifugal or an axial blower.

The combination of electrical generation and blowing was very much favoured on the Continent because Continental operators seemed to be wedded to the constant-speed blower. They seemed to be inclined to sell their blast-furnace gas to an electrical supplier and run motor-driven blowers. That was the drawback of any combination of electrical regeneration and blowing—it necessitated a constant speed.

Mr. Mathieson had suggested that the present-day gas-turbine efficiency obtainable was no higher than could be obtained from steam plant. With certain steam plant of the largest size and the highest steam conditions, that was probably still true. Mr. Mathieson referred to a 50 per cent. effective efficiency of the gas-turbine plant, as against 22·5 per cent., taking into account heat recovery. As the Sankey diagrams in the paper showed, the overall thermal efficiency of the blowing blast-heating operation, even with the low thermal efficiency, was over 50 per cent. His remarks about the comparative cost of the metallic air heater, as compared with stoves for temperatures of the order of 750 deg. C., were rather startling, and certainly added greatly to their attractiveness.

At this point the President asked Mr. Sayer to give the remainder of his reply in writing.

(To be continued)

★ ★ ★

ALUMINIUM IMPORTS

The Board of Trade announces that as from May 6 separate licences are no longer needed for the import from any source of unwrought aluminium, unwrought aluminium alloys, and aluminium, scrap. Details are given in Notice to Importers No. 729, dated April 29, 1955, and obtainable from the Board of Trade, Import Licensing Branch, 43, Marsham-street, London, S.W.1.

★ ★ ★

REMOVING DUST FROM FLUE GASES

Research in Electro-Precipitation

Dust, smoke, and grit can be removed from flue gases simply and efficiently by the use of electro-precipitators. The basic principle of electro-precipitation is the removal of solid or liquid particles from a gaseous carrying medium by giving the particles an electric charge and precipitating them on to a receiving surface in an electric field. The particles are charged by means of electrodes consisting of small-section wires or strips to which is applied a voltage of sufficient tension to form a corona discharge towards the receiving electrodes. The charged particles migrate to the receiving electrodes; from there they must be dislodged into a collector by mechanical rapping.

The principle is simple, but many difficulties arise in practice. The corona discharge depends on the shape and size of the discharge electrodes, the electrode spacing, and the temperature and nature of the gases between the electrodes. Two other problems in electro-precipitation are: to remove the precipitated material to make way for more deposits; and to eliminate complications due to the presence of collected material on the electrodes. The performance of precipitators is naturally greatly affected by the resistivity of the dust in the flue gases, and measurement of the resistivity also present difficulties.

These and other problems were discussed in a paper given on April 16 to the North-Western branch of the Institution of Chemical Engineers.* The results given were those obtained from research work both in the laboratory and with industrial precipitator plants. Three types of discharge electrode were used:

(1) Twisted wires; $\frac{1}{16}$ in. square section.
(2) Sharpened strips; $\frac{3}{16}$ in. wide by 0·015 in. thick.
(3) Barbed wires; four strands of $\frac{1}{32}$ in. wire with 0·011 in. diameter barbs spaced at $1\frac{1}{2}$ in. intervals, $\frac{1}{16}$ in. overall lengths.

Hitherto most of the work done on this subject has been empirical, and the conclusions drawn from the work done by Dr. Lakey and Mr. Bostock are most instructive for designers of precipitators. The results of their work so far are summarised below.

It is common practice to include a protective resistance in the discharge circuit. There appears to be a particular value of resistance which gives maximum current prior to breakdown. As the current passing is an indirect measure of precipitation efficiency it is important that due regard be paid to the value of the protective resistance inserted in the circuit, bearing in mind the power unit protection desired.

There is no gain in discharge current by using a large number of wires spaced closely together. To a first approximation, maximum current will be obtained for any particular arrangement when the distances between the wires are of the same order as those between wires and plates.

The type of discharge wire used has a marked effect on the discharge current and general stability. Within the limits of the types tested barbed wires has been found to give the most stable discharge conditions.

The resistivity of the material to be precipitated greatly effects the efficiency of the process, and most of the work concerning this factor is connected with its measurement under various conditions. Although the composition of the dust exercises considerable influence on its resistivity, the results suggest that there are other properties, not necessarily connected with composition, which can cause effects equally large. It is known that the "difficult" dusts are not restricted to those of very high or very low resistivity, and isolation of the various factors affecting precipitation efficiency could form the basis of future work in this field.

Dust accumulations on the electrodes lead to a reduction in the discharge current and efforts to restore this by increasing the high-tension potential cause back-discharge and spark-over. The effect is most marked for accumulations on the discharge wires, and it is interesting that back-discharge effects were least for the barbed electrodes.

Re-entrainment is shown to be affected by both particle size and resistivity; the larger the particle size and the lower the resistivity the more readily does re-entrainment take place.

Besides the problems mentioned above, there are many of a more fundamental nature which warrant investigation. Among these the following may be regarded as of primary importance: migration velocity related to particle size for various discharge characteristics, effect of gas composition and gas temperature on ionic mobility, and the measurement of electric-field strength under dust-laden gas conditions.

* "Researches into Factors Affecting Electro-precipitation," by J. R. A. Lakey, Ph.D., A.Inst.P., and W. Bostock, B.Sc.

COMPARATOR FOR GAS-TURBINE BLADE ROOTS*

MEASURING PITCH ERRORS IN FIR-TREE SERRATIONS

By L. W. Nickols, B.SC.(ENG.), M.I.MECH.E., A.M.I.PROD.E.†

In this paper is described a new comparator which has been designed to measure quickly and with high accuracy the spacing of the pressure-flanks of the serrations on gas-turbine blade roots, that is, the flanks that take the load under operating conditions.

The tolerances on the spacing or pitch of the serrations on the "fir-tree" roots of gas-turbine blades are very small, amounting to only a few ten-thousandths of an inch. In order to verify that the pitch errors are within these tolerances an accuracy of measurement of the order of $\pm 0{\cdot}000\ 05$ in. ($\pm 1{\cdot}25\mu$) is desirable, and at the same time a high speed of measurement is required in order to cope with large numbers of turbine blades. To satisfy these two main requirements a new comparator, for which a patent application has been made, has recently been designed and constructed at the National Physical Laboratory. This comparator measures the pitch of the pressure-flanks of the serrations, but it may also be easily adapted to measure the pitch of the centres of the grooves.

PRINCIPLE OF OPERATION

The turbine blade is mounted in the workholder of the comparator at such an angle that the pressure-flanks of all the serrations on one side of the root lie in horizontal planes; this arrangement is shown diagrammatically in Fig. 1. The pitch of these pressure-flanks is then obtained by measuring their vertical heights above the pressure-flank of the lowest serration, which is held in contact with a horizontal datum surface on the workholder. These measurements are made by means of the turret, shown in Figs. 2 and 3, which rotates about a vertical axis and carries a number of styluses arranged radially around its periphery. Each stylus is mounted on a spring-strip suspension so that it is free to move in a vertical direction. As the turret is rotated each stylus in turn engages with the serration it is intended to measure and, through the medium of an adjustable strut, registers its vertical height on a single comparator head placed directly above the serrations. Adjustments are provided to enable the instrument to be set correctly with the aid of a simple setting fixture, and the comparator head then records directly the errors of pitch of the pressure-flanks with reference to the lowest pressure-flank.

In one revolution of the turret the errors of pitch of all the serrations on one side of the turbine-blade root are determined. The pitch errors of the serrations on the other side of the root are measured after reversing the blade in the workholder.

The turret is rotated by an electric motor, and

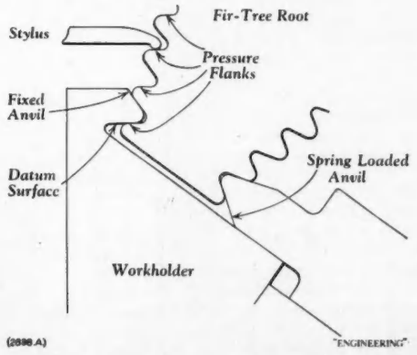


Fig. 1 "Fir-tree" root of a turbine blade secured in the comparator workholder. The vertical distance between corresponding pressure-flanks is measured by means of a stylus.

* Communication from the National Physical Laboratory.

† Principal Scientific Officer, Metrology Division, National Physical Laboratory.

suitably mounted cams, which operate a micro-switch, enable the speed of rotation to be reduced at the measuring positions to facilitate reading of the comparator head. The addition of further workholders and comparator heads arranged radially around the turret is possible if the design is slightly modified, thus permitting a number of turbine blades to be inspected simultaneously. The various parts of the instrument are described in more detail in the following paragraphs.

FEATURES OF THE COMPARATOR

The Workholder.—The turbine blade is mounted in a clamp (Figs. 2 and 4) consisting of two collinear fixed anvils (A) which engage with the lowest serration on one side of the blade, and a spring loaded anvil (B), placed centrally between the other two anvils, which engages with the corresponding serration on the other side of the blade. When the blade is clamped in position both flanks of each of the anvils are in contact with the flanks of these serrations, and there is a clearance between the crest of each anvil and the radiused root of the serration. In the measuring position the pressure-flank of the lowest serration on one side of the blade root is held against the horizontal datum surface (Fig. 1) of the workholder, which is itself parallel to the base of the workholder and normal to the axis of pitch measurement.

The workholder may be moved along a dove-tail slide on the baseplate of the comparator in a direction tangential to the circles swept out by the measuring styluses, thus permitting the uniformity of the pitch along the lengths of the serrations to be explored. The workholder is clamped in any position along the length of this slide by means of a gib strip and clamping screw.

The Turret.—The turret (Fig. 2) rotates on plain bearings about a vertical column (C) mounted on the base-plate and its weight is taken by a ball bearing. The body of the turret (Fig. 3) has symmetrically disposed flats machined on its periphery, the flats being one less in number than the serrations on one side of the turbine-blade root. Each flat carries a strut assembly (D) (Fig. 4) mounted on two similar pairs of spring-steel strips (E); each pair is in the form of a V, one being attached to the upper part and the other to the lower part of the strut assembly. This form of suspension utilising two parallel V-pieces provides freedom of movement in a vertical direction with excellent lateral rigidity.

SENSITIVE ADJUSTMENT OF STRUT LENGTH

Each strut assembly comprises a lower block (F) (Fig. 2) which is connected to an upper block assembly (G) by means of a strut (H), the length of which is adjustable. The lower block carries the measuring stylus, and the upper block assembly operates the comparator head by means of the ball (J). The strut is constructed of two parallel spring-steel strips connected together rigidly at the ends. Each of the two strips has a central plate attached by means of "Araldite." By pulling the two central plates towards each other by means of the central adjusting bolt (K) the overall length of the strut is reduced. This type of strut* has the advantage that it can provide a high sensitiveness of adjustment of the overall length in combination with a large range of setting. The particular strut employed on this comparator has a sensitiveness of adjustment of 0·00001 in. (0·25μ) combined with a range of length adjustment of about 0·005 in. (125μ). In addition to this fine adjustment, a rough adjustment of the overall length of the strut assembly is provided by means of the slotted hole (L) in the upper block assembly.

The overall lengths of the strut assemblies are nominally the same, but each stylus is at a different height from the base of the lower block, according to the serration it is intended to measure. The projection of each stylus beyond the vertical face of the lower block may be adjusted by the grub screw (M).

* Nickols, L. W., "An Adjustable Strut for Use in Measuring Instruments." *J. Sci. Instrum.*, vol. 32, page 149 (1955).

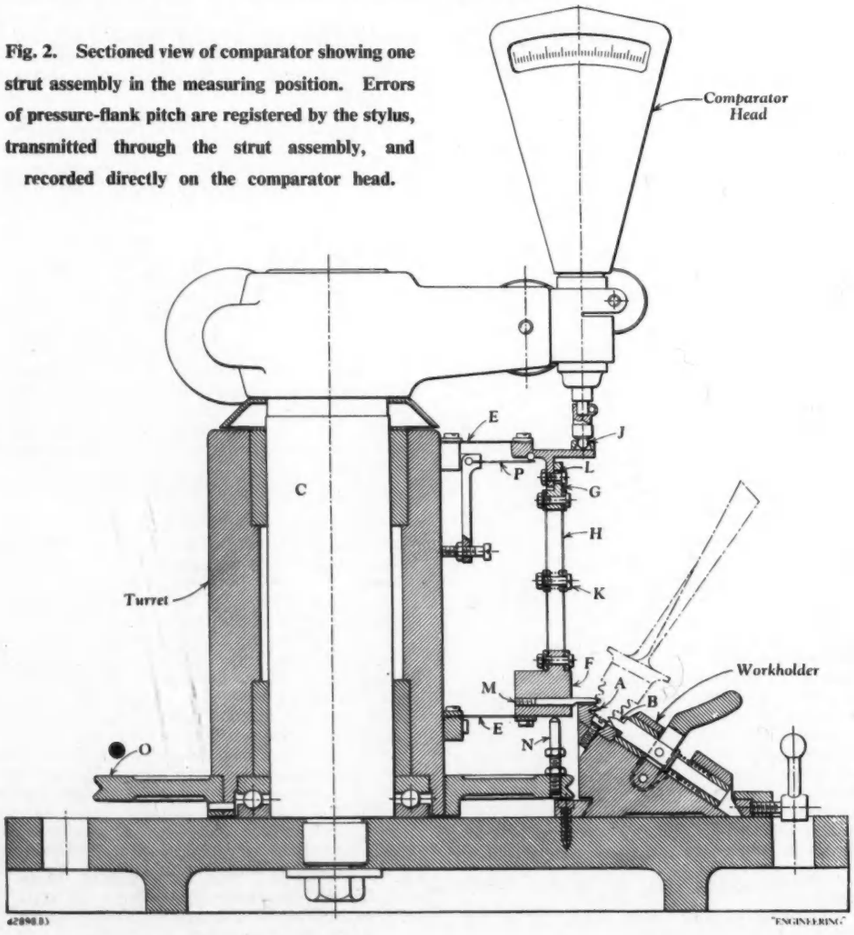


Fig. 2. Sectioned view of comparator showing one strut assembly in the measuring position. Errors of pressure-flank pitch are registered by the stylus, transmitted through the strut assembly, and recorded directly on the comparator head.

ROTATING TURRET

An end-stop (N), with a screw adjustment, is provided for each strut assembly. Each end-stop is set so that when the stylus is disengaged from the serration on the blade, the stylus is a few thousandths of an inch below its measuring position. When the stylus is moved round to enter the serration the radius on the stylus provides a "lead-in" so that it engages without shock. The end-stops are mounted on a large-diameter pulley (O) which is fixed to the base of the turret. The latter is rotated by an electric motor which drives a belt engaging with a V-groove on the periphery of the pulley. On the upper surface of the pulley, cams are arranged mid-way between the end-stops. These cams operate a micro-switch, mounted on the base-plate of the comparator, which switches an extra resistance into the motor circuit just before each stylus engages with its serration, thus slowing down the turret to assist the stylus to engage without shock, and to facilitate reading of the comparator head.

An arrangement for adjusting the measuring force on each stylus is provided in the form of a leaf spring (P) which bears on a ball fixed to the underside of the upper block. This leaf spring is attached rigidly to a lever which pivots on the body of the turret so that when the set screw at the end of the lever is suitably adjusted an upward force is applied to the strut assembly.

Measuring Styluses.—The upper part of each stylus is cut away so that it clears the flank opposite the pressure-flank of the serration. The contact face is approximately spherical in shape to provide a lead-in to the serration as the turret is rotated and to localise contact to the mid-point of the pressure-flank. The stylus is normally of hardened steel but may be faced with a wear-resistant material such as tungsten carbide.

The Comparator Head.—A sensitive comparator head is mounted, with its measuring axis vertical, in a split clamp on an arm attached rigidly to the central column (C). The clamp permits vertical adjustment of the comparator head. The comparator anvil has a spherical contact surface of large radius, and to reduce wear is faced with tungsten carbide.

The Setting Fixture.—The base of the setting fixture (Fig. 5) has its upper and lower faces finished accurately flat and parallel. On top of the base are clamped a number of setting pieces, each having accurately flat and parallel upper and lower faces, and of a thickness equal to the basic pitch, measured normal to the pressure-flanks, of the serrations on the turbine blade. Between the upper face of the base and the lowermost setting piece are interposed slip gauges so that the height of the uppermost slip gauge above the lower face of the base is equal to that of the datum surface above the base of the workholder (Figs. 1 and 5). The setting pieces have their leading edges relieved and are staggered by the same amount as the corresponding serrations of a turbine blade held in the workholder. When the setting fixture is placed on the baseplate of the comparator the upper surfaces of the setting pieces are at the same heights above the baseplate as the pressure-flanks of a perfect turbine-blade root held in the workholder.

SETTING AND OPERATING THE COMPARATOR

The workholder is removed from its slide on the baseplate and is replaced by the setting fixture. The turret is rotated until the lowermost stylus is in the measuring position, in contact with the appropriate gauging face of the fixture and directly under the comparator head. By means of the slotted hole (L) in the upper block assembly (G) the length of the strut assembly is

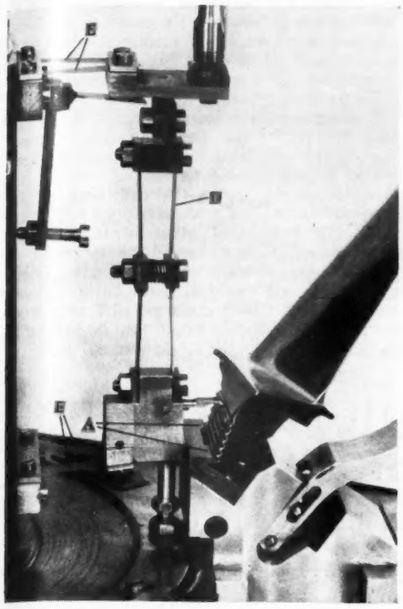


Fig. 4 The stylus is mounted on a block attached to two flat supporting springs and also to the strut assembly. Adjustments to strut length are made by turning the centre screw, which gives both sensitivity and wide range of setting.

adjusted until a reading is obtained on the comparator head. The fine adjustment (K) of the strut is then used to produce a zero reading. The measuring force is then adjusted by means of the leaf spring (P) to about 8 ounces (225 gm.) and, if necessary, the zero reading re-set. The end-stop (N) is then adjusted until it is about 0·002 in. (0·05 mm.) below the lower block (F) in the gauging position.

The above procedure is repeated in turn for the other styluses. The setting fixture is then replaced by the workholder and a turbine blade inserted in the latter. The readings obtained on the comparator head as the turret is rotated are the errors of spacing of the pressure-flanks

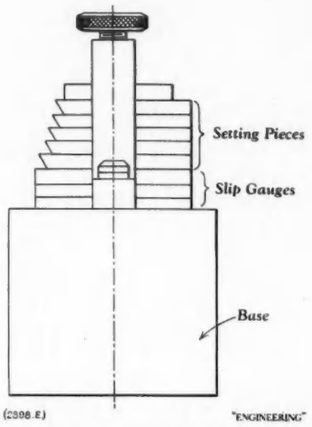


Fig. 5 When the setting fixture, shown here, is placed on the comparator baseplate, the upper surfaces of the setting pieces are at the same height as the pressure-flanks of a perfect turbine-blade root gripped in the workholder.

with reference to the lowest pressure-flank as a datum.

MEASURING THE PITCH OF SERRATION CENTRES

The comparator described above has been constructed to measure the pitch errors of the pressure-flanks of the serrations. If it is desired to measure the pitch errors of the centres of the serrations, which are dependent on the spacing of both flanks, then the following modifications to the design are required. It is assumed in this case that the pitch measurements are to be made in a direction parallel to the longitudinal axis of the root. The workholder is modified to hold the turbine blade vertically (Fig. 6) and the pitch of each of the serrations is measured with reference to the centre of the lowermost serration, using a stylus which contacts both flanks of a serration when in the measuring position. The lower block (F) of the strut assembly is modified as shown in Fig. 7, with the stylus mounted in block (Q), which is attached to the ends of two pairs of parallel vertical leaf springs (R). As the turret is rotated, the stylus enters the serration

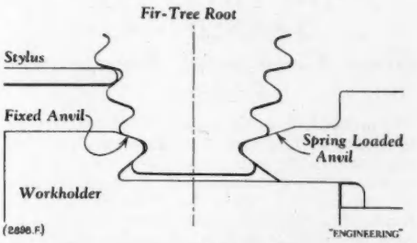


Fig. 6 To measure the pitch of serration centres it is necessary to modify the comparator; the turbine blade is then held vertically.

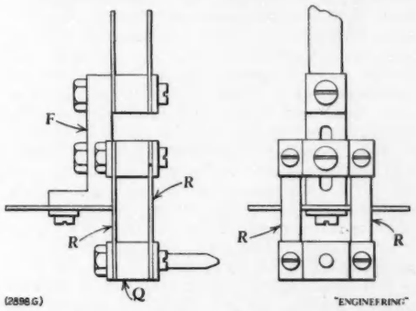


Fig. 7 The lower part of the strut assembly also requires modification when the comparator is adapted to measure the pitch of the centres of serrations.

being measured and the leaf springs keep it in contact with both flanks. The setting standard may be a turbine-blade root having known errors of pitch, and allowance can be made for these errors when adjusting the lengths of the struts.

Acknowledgment.—The author desires to acknowledge the help of Mr. J. E. Furse in the design and experimental work involved in the production of the comparator.

The project was carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

Fig. 3 The comparator in operation. Speed of working is achieved by using a rotating turret carrying several stylus heads; thus in one revolution, the pitch errors of all serrations on one side of the blade root can be measured.

★ ★ ★

TEMA HARBOUR

Model Tests at Research Station

The Hydraulics Research Station, Wallingford, has contracted to carry out two investigations for Sir William Halcrow and Partners, consulting engineers, in connection with a new harbour which it is proposed to construct at Tema on the Gold Coast.

One investigation will be carried out on a large model of Tema Harbour built to an undistorted scale of 1/120 in Wave Basin No. 1. This model will be used in studying the behaviour of long and short-period waves in and around the harbour. Such tests are necessary to ensure that ships using the harbour will be suitably protected from wave action. The present design of harbour in its various stages of development will be tested in the model and, subsequently, the effects of shortening the breakwaters, and of other modifications, will be examined.

The other investigation is concerned with the stability of the breakwaters of Tema Harbour. These breakwaters will be constructed of large rubble, and will inevitably be subjected to severe wave action. Their behaviour under storm conditions is at present being studied on a model of a typical section of the breakwater built in the 54-ft. wave tank to an undistorted scale of 1/40. The tests will indicate in what way the large rocks—which will form the greater part of the breakwater—should be arranged and graded so that they will remain undisturbed by the largest waves.

THE PHYSICS OF TRANSISTORS

Great Commercial Development Probable

The proceedings at the meeting of the Institution of Electrical Engineers on Thursday, April 21, opened with the presentation of a certificate of honorary membership to Mr. J. R. Beard and of the Faraday Medal for 1955 to Sir John Cockcroft. The forty-sixth Kelvin Lecture was then delivered by Dr. W. Shockley, who took " Transistor Physics " as his subject.

Dr. Shockley said that most of the work in the field of transistor physics had been done on germanium and silicon, but there was a possibility that other materials would become important. Of the two materials mentioned germanium was the better controlled. It was easier to purify than silicon although it had certain drawbacks. The advantage of silicon on the other hand was that it operated better at high temperatures, the fundamental reason being that it was more tightly bonded than germanium, and therefore had a higher melting point. Although it was harder to find crucible materials for dealing with it, and harder to purify, the additional tightness of the bonding put it far ahead of germanium in high-temperature applications.

The five imperfections in a germanium or silicon crystal, a knowledge of which was necessary to a preliminary understanding of transistor physics, were excess electrons, holes, deathnium, donors and acceptors. The physical and chemical features involved were important in making germanium and silicon to carry out experiments. Dr. Shockley then continued by describing a P-N junction and said that methods of making almost pure germanium had been devised, using a technique known as zone refining which had originated in the Bell Telephone Laboratories. One of the simplest methods of making compositional structures, such as a P-N junction, was by invoking the principle of compensation, that is by introducing ions to balance the charge of the ions already present. Another method, which had recently been employed, had proved particularly effective with silicon and promised to be useful generally; its basis was the growing of an N-type crystal.

CONVERSION OF SOLAR INTO ELECTRICAL ENERGY

P-N junctions had been used in the Bell solar battery for the conversion of solar energy into electrical energy, in which they had an efficiency of at least 10 per cent. Whether this would be a practical development would depend on, economics, how easy it was to make the junctions, capital investments, and so on. The solar battery appeared, however, to be practical in communications, and there was to be a trial installation in which it would be used on rural lines. The design was such that if the sun shone for 15 hours a week on the solar battery, it would keep the storage battery charged and the system would work. This development had been made possible by the low power range of the junction transistor. Silicon units, however, were equally good as high-power devices.

COMMERCIAL APPLICATIONS

There had, been Dr. Shockley said, two large commercial applications of transistors in America—in hearing aids and in portable radio. For hearing aids the transistor was valuable since no filament was necessary and it led to a considerable saving in battery costs.

The present rate of production of transistors was comparable with that of vacuum tubes in 1920. If the production increased as might be expected, there would be a corresponding drop in costs and certainly a bigger market with applications where probably it was not economic to use tubes at present.

In conclusion, the lecturer remarked that he was very optimistic regarding the ultimate potentialities of transistors. A field had been opened up comparable to that of vacuum and gas discharge electronics. Already several transistor structures had been developed and many others explored. Still other ideas had been produced which had yet to be subjected to adequate experimental tests. It seemed likely that many inventions would be made based on these principles, and it was quite possible that other new physical principles would also be utilised in practical industry as the art developed.

ELECTRIC DYNAMOMETER OF HIGH PRECISION

AIR-LUBRICATED TRUNNION BEARINGS EMPLOYED

By D. Firth, A.M.I.MECH.E.*

A high-precision swinging-frame electric dynamometer has been developed for measuring the efficiency of hydraulic machinery. It is accurate to within ± 0·1 per cent. of full-scale torque and is reasonably portable. Novel features include pneumatic trunnion bearings, hydraulic torque measurement, and electronic speed control to within 0·1 per cent. over a wide range. The development of the design is described and design features for larger dynamometers are suggested.

Introduction.—High-precision electrical dynamometers were required for the new hydraulic machinery building of the Mechanical Engineering Research Laboratory, East Kilbride. Accuracies to within ± 0·1 per cent. of the full-scale torque and the rotational speed were required and the dynamometers were to be capable of being easily moved around the building. As conventional dynamometers did not meet these requirements, a special design was developed at the Laboratory, using a converted direct-current motor giving 25 h.p. at 3,000 r.p.m. Novel features, including pneumatic trunnion bearings, hydraulic torque measurement and electronic speed control, have resulted in a unit of unusually high accuracy. The development work has also suggested new ideas for larger dynamometers.

* Fluid Mechanics Division, Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

TRUNNION-BEARING DESIGN

Three types of trunnion were investigated: simple ball-bearing pedestals, ball-bearing pedestals with the outer races rotated, and pneumatic bearings. The bearings were fastened to the end-shield facings of the dynamometer and the whole assembly mounted on a base-plate. With the conventionally-mounted ball-bearing trunnions, friction introduced an error of ± 0·9 per cent. of the full-load torque of the dynamometer, even though great care had been taken to align the pedestal bearings correctly. The same ball races were supported in needle-roller bearings and the outer races were rotated in contrary directions by variable-speed electric motors. This reduced the frictional loss to 0·007 per cent. of full-load torque, after taking special care with alignment and lubrication. The same frictional loss was obtained with a similar set of bearings. Although the friction of the two contra-rotated bearings on the dynamometer was not exactly comparable, it did not vary greatly with speed. A speed of 45 r.p.m. was used to prevent the introduction of vibration from the driving motor. The best lubricant found was a light machine-oil thinned with kerosine. Some " running-in " of the bearings was noticed. This, together with the fact that bearings with different friction/speed characteristics had been used, suggest that an even lower frictional loss could be obtained by

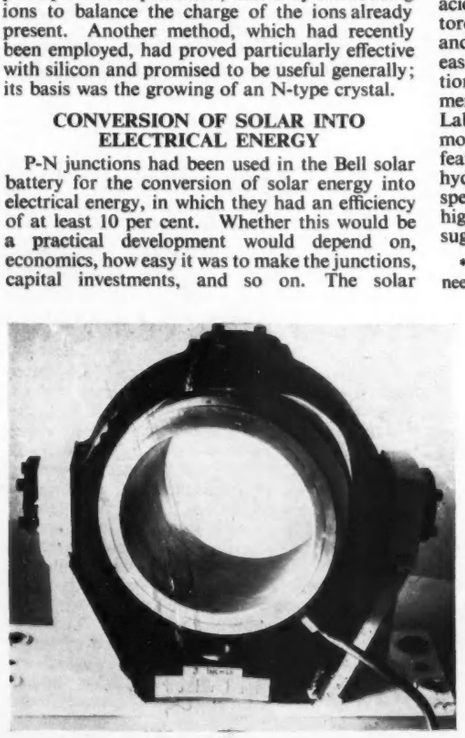


Fig. 1 Pneumatic trunnion bearing mounted in gimbals; this arrangement allowed each bearing to find its best alignment, thus eliminating costly precision manufacture elsewhere in the dynamometer.

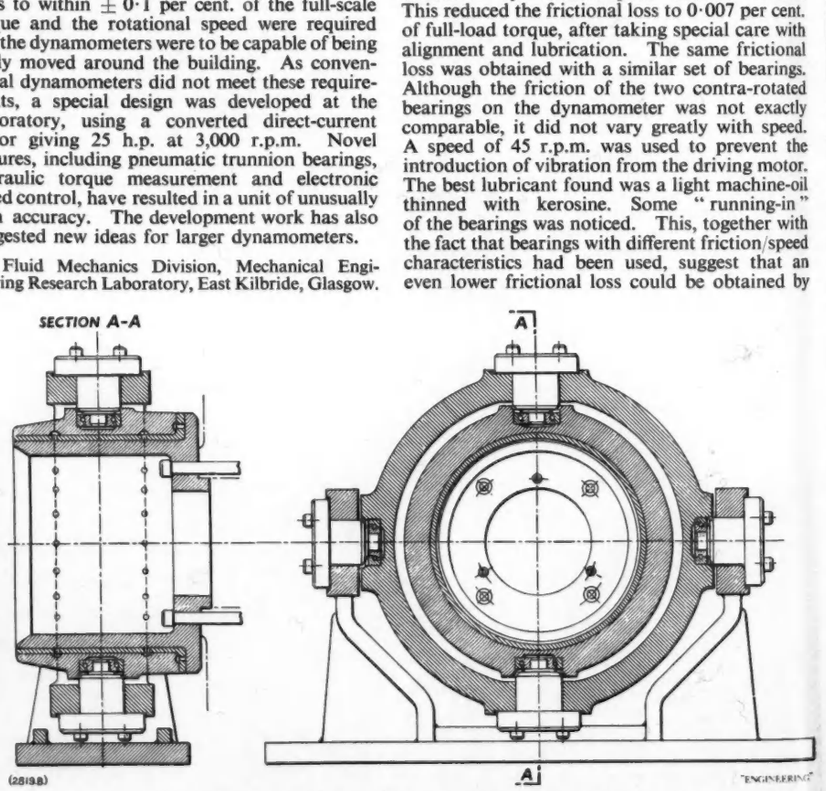


Fig. 2 General arrangement of the air-bearing pedestal; air consumption is 15 cub. ft. of free air per minute.

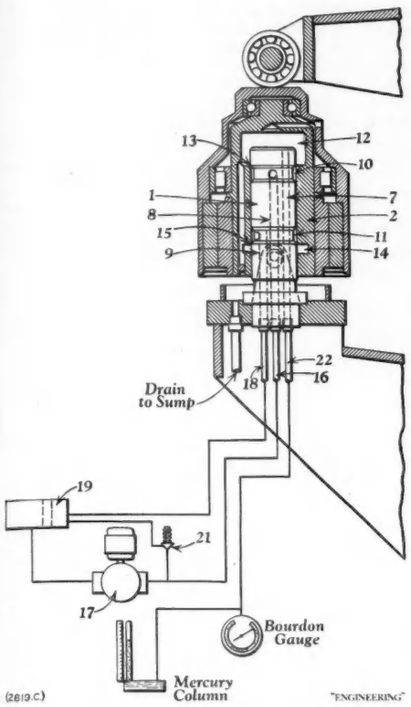


Fig. 3 Details of the rotating hydraulic valve with stationary piston (shown here in null position) for accurately measuring the torque thrust.

using selected bearings that had been carefully "run in."

It was decided to use pneumatic bearings for the 25-h.p. dynamometer. They were designed as simple sleeve bearings with the journal suspended in gimbals (Fig. 1). This enabled each bearing to find its best alignment, thus eliminating the need for costly precision manufacture elsewhere. Air at 80 lb. per square inch pressure was fed into each bearing through 20 circumferential holes, 0·021 in. in diameter. The bearings, the design of which is illustrated in Fig. 2, opposite, were 6 in. in diameter by 5 in. long, with a diametral clearance of 0·0035 in., and together supported a total load of 1,100 lb. The friction of these bearings was too small to be measured when in clean running condition, but a very small amount of dirt greatly increased the coefficient of friction. To meet this requirement for clean air, the air compressor should be of the "oil-less" type, fitted with after-coolers, a drier, and an efficient filter.

A disadvantage of pneumatic bearings is their large air consumption. These bearings used 15 cub. ft. of free air a minute, but the air supply was required only when a torque reading was made. Another disadvantage of pneumatic bearings is their size compared with that of the dynamometer being supported. The proportions are reasonable for small units, but the bearings become disproportionately large for dynamometers above about 25 h.p. Oil-lift trunnion bearings[1] are probably suitable as frictionless bearings for larger dynamometers. They are similar in principle to pneumatic bearings but higher pressures are obtained with lower flow rates by using oil in place of air. The dimensions of these bearings are, therefore, smaller and the cost of the high-speed oil pump is less than that of the air compressor. By using oil of low viscosity, it would seem that the coefficient of friction would be sufficiently low to meet the requirement of high-accuracy dynamometers. They, also, have certain disadvantages: as with air bearings, dirt particles are inimical to high sensitivity; temperature changes in the oil produce variations of film conditions in the bearing; and the possibility of leaks from the oil system calls for special protection of other parts of the dynamometer.

TORQUE MEASUREMENT

The unit for measuring torque below 1,600 in-lb. is shown in Fig. 3. It comprises a rotating hydraulic valve on a stationary piston operated by an arm extending from the carcase of the dynamometer. The piston 1 contains three ducts 7, 8, 9; the duct 7 opening in the upper end of the piston and the ducts 8, 9 into the grooves 10, 11 in the piston near its upper and lower ends. At the upper end of valve 2 is an enlargement 12 which forms an upper shoulder 13, while a groove 14 in its wall defines a lower shoulder 15. A duct connects the groove 10 with the enlargement 12. The distance between shoulders 13 and 15 is equal to the distance between the outer edges of the grooves 10 and 11 in the piston. Thus in the null position shown in Fig. 3, these shoulders are in register and both piston grooves are covered. The null position is indicated by a steady pressure reading. Immediately the cylinder moves axially, communication is established between the cylinder space and one or other of the grooves.

The upper groove 10 communicates through its duct 8 and a pipe 16 with a continuously-driven gear pump 17, so that if the cylinder descends liquid under pressure is admitted to raise the cylinder until it again reaches the null position. At the same time the lower groove 11 communicates through its duct 9 and a pipe 18 with the sump 19, so that if the cylinder rises above the null position, oil can escape to the oil sump until the cylinder returns to the null position. A small negative lap of 0·0015 in. was found necessary for stable operation. The gear pump 17 draws from the sump 19, and to provide for conditions when the cylinder is at or above null position, a relief valve 21 discharges the pump supply back to the sump. The assembled unit is shown in Fig. 4.

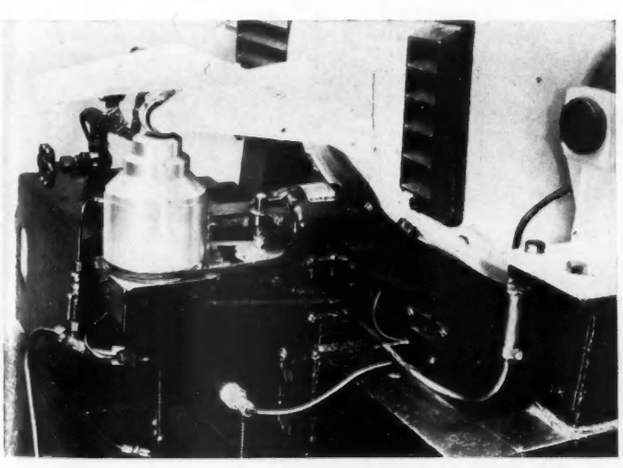


Fig. 4 The assembled hydraulic torque-measuring unit shown fitted in position; it is used for torques up to 1,600 lb.-in.

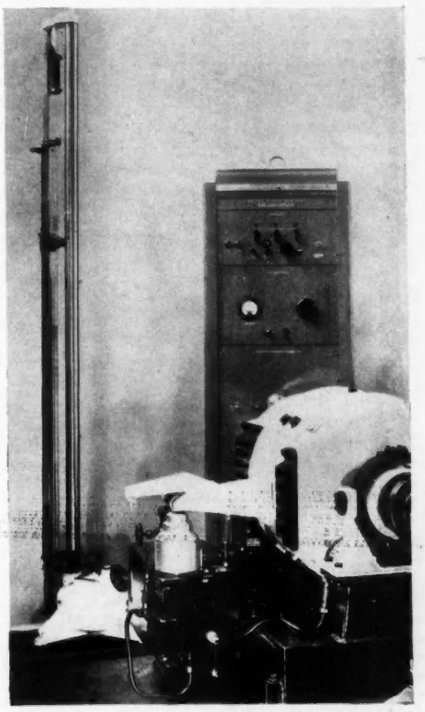


Fig. 5 The complete dynamometer assembly with the mercury manometer on the left.

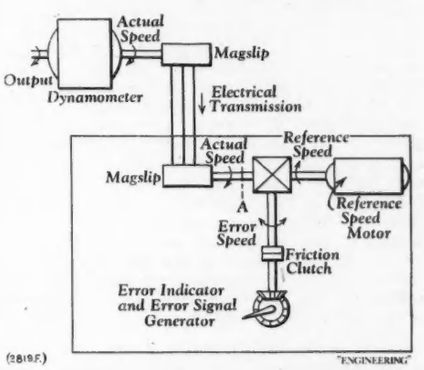


Fig. 6 The speed-control system; the reference speed is obtained from a synchronous motor operated from a supply of accurate frequency.

Pressure from the cylinder head is transmitted through duct 7 and pipe 22 to a pressure measuring unit. In the tests described this was a 2-metre mercury manometer reading to 0·02 mm., which was the maximum sensitivity of the installation. The unit works satisfactorily with a Bourdon test gauge, which can be arranged for remote reading, but the accuracy and the sensitivity are not as high as with the mercury column. To minimise friction the cylinder was rotated relative to the piston, thus maintaining a continuous fluid film between the working surfaces. Provided that dust particles can be filtered from the hydraulic fluid, wear can thus be almost eliminated. Michell[3] has demonstrated the effectiveness of rotation, and an accuracy of 1 part in 10,000 has been claimed[2] for deadweight gauge testers which use the same principle. Only secular changes can affect the calibration and such effects can be eliminated if stable materials are used. Other well-established methods are to impose a high-frequency "dither" to one of the components, or a high-frequency pulsation to the fluid between the pressure sensing and measuring elements. However, as it was considered important in

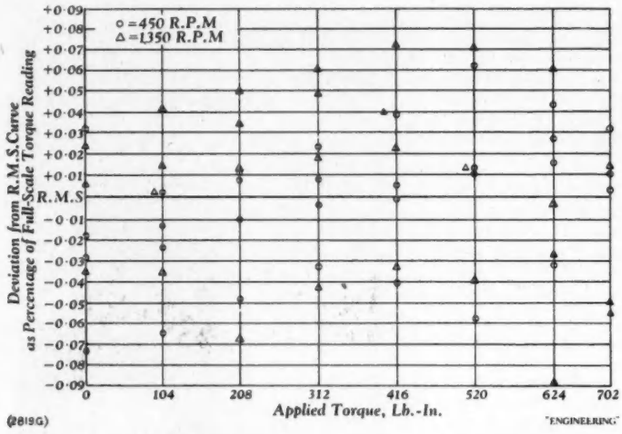


Fig. 7 A typical calibration record showing the errors as deviations from the R.M.S. value of a number of static calibrations. The relation between manometer reading and torque is linear.

the interests of accuracy to avoid pulsations, the rotational technique was adopted.

DYNAMOMETER ASSEMBLY

The 25-h.p. dynamometer is shown in Fig. 5, page 629. The motor carcase with its supporting feet cut off flush with the body was mounted through the pneumatic bearings on a rigid frame fabricated from mild steel. The torque arm attached to the motor frame was arranged with an extension to enable the dynamometer to be calibrated using deadweights, a small knife edge being provided for the weight hook. To eliminate drag on the carcase, all electrical connections were made to the motor through mercury pots. With certain types of dynamometers, the load indicated is proportional to the displacement of the torque arm from a zero position. On such machines careful calibration is needed to eliminate secondary effects harmful to the accuracy of the dynamometer, such as the change in the centre of gravity of the dynamometer carcase with change of load, and the deflection of the electrical leads to the dynamometer. If mercury pots are used in place of flexible leads, they should be so arranged that the buoyancy of the mercury does not affect the accuracy. These effects are reduced to a minimum with the null-reading type of dynamometer described here. The armature was supplied from a direct-current generator. The supply to one half of the split field came from the direct-current mains and the other half was fed from a thyratron amplifier in the speed-control unit.

SPEED-CONTROL UNIT

The need for a speed-control unit was demonstrated when the assembled dynamometer was run with and without speed control. With speed control the manometer reading was steady but without it the reading varied with changes in speed. The manometer fluctuated in synchronism with the differential indicator in the speed-control unit. For the type of work for which this dynamometer was intended, the repeatability of a speed setting was essential. A commercial speed control was therefore chosen which enabled a speed to be set and automatically maintained within close limits.[4] The basis of this system is illustrated diagrammatically in Fig. 6. The "reference speed" motor is a synchronous motor operated from a supply the frequency of which is accurately fixed. In the basic system this frequency is determined by a tuning fork, and a 30-watt amplifier provides the power for the synchronous motor.

When the dynamometer shaft is running at exactly the same speed as the "reference" motor, the output shaft from the differential connected between the two motors is stationary. Any small departure of the dynamometer from the correct speed causes a slow rotation of the output shaft from the differential; the direction of rotation indicates whether the speed is high or low. A friction clutch between the differential and the error-output shaft prevents damage to the differential which would be caused by a prolonged error in speed. An electrical system, operated by the shaft, controls the output of the thyratron amplifier to the dynamometer field and corrects the dynamometer speed until the differential is stationary.

The range of operating speeds was obtained by interposing a mechanical gearbox at point A, Fig. 6. This gearbox allowed the selection of any one of 900 ratios over a range of 10 : 1 in steps of 0·1 per cent. The ratios were selected by three decade dials arranged so that the number selected on the dials directly indicated the speed of the dynamometer.

TORQUE CALIBRATION OF THE COMPLETE DYNAMOMETER

The relation between manometer reading and torque is linear. The inaccuracies of the system are too small to be shown on a conventional calibration curve, and the results are therefore shown as deviations from the R.M.S. value of a number of static calibrations in Fig. 7, herewith. These results were obtained over the course of a working day with the dynamometer and the torque-measuring gear running continuously. The greatest variation from the R.M.S. value, based on a series of static calibrations, represented an accuracy to within $\pm$ 0·09 per cent. at full scale of the dynamometer.

It is customary on most dynamometers of this kind either to establish calibration curves at different speeds for eliminating the effect of windage on the torque reading, or to use some scheme of windage elimination on the dynamometer itself. When the work was first started, it was fully intended to fit windage eliminators but, as can be seen from the final calibration runs in Fig. 7, they were not necessary.

When working for long periods continuously, slight drifts in zero readings were found to coincide with changes in temperature of the oil in the torque-weighing system. An explanation of this effect can be found in the leakage caused by deficiencies in manufacture of the torque-weighing cylinder, and the effect of temperature on the mercury column. The specified clearance between the piston and the sleeve was 0·0005 in., whereas the manufactured clearance became 0·0025 in. Nevertheless, even with this increased clearance the measuring gear met the requirements. The total sustaining load of the piston is the product of the working pressure and the effective area, plus the shear associated with the leakage between the pressure and the exhaust ports along the valve boundary. Thus for a constant load on the piston, any alteration in the leakage rate affects the proportion between the two components.

Even though the error was within the specified limits of accuracy, steps are being taken to reduce it. These include a new piston and cylinder with the correct working clearance and a reduction of the temperature range of the working fluid by altering the by-pass arrangements at the pump. A unit for measurements of torque greater than 1,600 lb.-in. is also being developed.

Acknowledgments.—The work described has been carried out as part of the research programme of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Mechanical Engineering Research. Thanks are also due to Messrs. P. Harrison, J. D. Hamilton and R. H. Y. Hancock for their assistance with the experiments.

REFERENCES

[1] Potts, B. S. "Hydrostatic Bearings," *Machine Design*, pages 180–184, vol. 24, No. 10, Oct., 1952.
[2] Michell, A. G. M. "Effect of rotation on the Sensitivity of an Absolute Pressure Balance." *Annalen der Physik*, No. 20, vol. 72, 1923.
[3] Meyers, C. H. and Jessup, R. S. "A Multiple Manometer and Piston Gauges for Precision Measurements," *Bur. Stand. J. Res.*, Washington, pages 1061–1102, vol. 6, 1931.
[4] Knapp, R. T. *The Hydraulic Machinery Laboratory at the California Institute of Technology.* Caltech-Hydrodynamics Laboratory Publication, No. 6.

★ ★ ★

LAUNCHES AND TRIAL TRIPS

S.S. "FORTHFIELD."—Single-screw oil tanker, built by Hawthorn Leslie (Shipbuilders), Ltd., Hebburn-on-Tyne, County Durham, for Hunting and Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 555 ft. 9 in. overall by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, about 18,000 tons. Double-reduction geared steam turbines, developing a maximum of 8,250 s.h.p., constructed by Hawthorn Leslie (Engineers), Ltd., Newcastle-upon-Tyne, and two Foster Wheeler water-tube boilers. Trial trip, April 13 and 14.

M.S. "MINIKOI."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, to the order of the Swedish-Eastasiatic Co., Gothenburg, for the joint use of that firm and the Swedish-American Line, Gothenburg, both organisations forming part of the Broström group of companies. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 38 ft. 6 in. to shelter deck; deadweight capacity, 8,575 tons on a draught of 25 ft. 9¼ in.; cargo-carrying capacity, 541,000 cub. ft. (including 37,000 cub. ft. refrigerated space). Eriksbergs-B. and W. seven-cylinder single-acting two-stroke Diesel engine, developing 8,300 b.h.p. Service speed 17 knots, fully loaded. Launch, April 14.

H.M.S. "CHICHESTER."—Air-direction frigate, built by the Fairfield Shipbuilding and Engineering Co., Ltd., Govan, for the Admiralty, London, S.W.1. Length 340 ft. overall, with a beam of 40 ft. Main armament comprises two 4·5-in. guns and two smaller guns. Propulsion provided by Admiralty standard-range Diesel engines. Launch, April 21.

M.S. "PRESIDENT KRUGER."—Single-screw cargo vessel, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Northern Steamships Ltd., Johannesburg. Second vessel for these owners. Main dimensions: 435 ft. 8 in. between perpendiculars by 59 ft. by 39 ft. 2 in. to upper deck; deadweight capacity, about 11,000 tons on a summer draught of 27 ft. 9 in.; total capacity, 616,300 cub. ft. Hawthorn-Doxford four-cylinder single-acting two-stroke opposed-piston oil engine, developing 4,400 b.h.p. at 115 r.p.m., constructed by Hawthorn Leslie (Engineers), Ltd., Newcastle-upon-Tyne. Launch, April 21.

M.S. "GANNSFJORD."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the joint ownership of Skips A/S Hidlefjord, and Skibs A/S Byfjord, Stavanger, Norway. Main dimensions: 550 ft. overall by 60 ft. by 39 ft. 3 in.; deadweight capacity, about 17,400 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Service speed, about 15 knots. Launch, April 21.

S.S. "BEARWOOD."—Single-screw cargo vessel, built by Austin and Pickersgill, Ltd., Sunderland, for William France, Fenwick & Co., Ltd., London, E.C.3. Main dimensions: 344 ft. overall by 46 ft. 3 in. by 22 ft. 4 in. to upper deck; deadweight capacity, about 4,600 tons on a mean summer draught of 20 ft. Direct-acting triple-expansion steam engine of reheat design, constructed and installed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by two oil-burning marine boilers. Service speed, 10½ knots. Launch, April 21.

INCREASING THE SPEED RANGE OF AIRCRAFT

DIRECT LIFT FROM ENGINE POWER

The application of powered lift to aircraft, which has become possible with the great reduction in aero-engine specific weights resulting from the development of jet propulsion, and the new types of air vehicle with a range of speed much wider than has hitherto been possible, to which powered lift may lead, were the subjects of the Trueman Wood lecture entitled "New Ways of Flying," delivered recently before the Royal Society of Arts in London by Major Oliver Stewart, M.C., A.F.C. We give below extracts from Major Stewart's paper.

All aircraft operators, and most aircraft users, would like to combine the landing and taking off powers of the helicopter with the top speed and economical cruising powers of the fixed-wing aeroplane. Attempts to step up the speed of rotorcraft have usually taken the form of a mingling of fixed wing and moving wing, as in the Fairey Gyrodyne, which used a pair of small fixed wings and had the airscrew offset at the starboard wing tip. In this way, the drag of the anti-torque rotor at the tail of the conventional helicopter was eliminated. It vibrated less than the conventional helicopter of its time, and it was faster.

A more radical approach to improved helicopter speeds is the true convertible aircraft, as in the Bell XV-3, (Fig. 1) with fixed wings and twin three-bladed rotors. The rotor masts can be tilted from vertical to horizontal and so can be converted from the function of lifting to that of propelling. Its design speed is 282 km. an hour, 31 km. an hour faster than the existing official helicopter speed record. The Bell company state that conversion back from aeroplane to rotocraft can be performed with engine off and that, in an emergency, an autorotative landing can be made.

Between rotorcraft and fixed-wing aircraft there is a type of machine that is "neither fish nor flesh nor good red herring." It is represented by the Lockheed XFV-1 Salmon (Fig. 2), which was announced on March 17, 1954, and by the Convair XFY-1 Pogo (Fig. 3), which made a successful free vertical take-off on August 1, 1954. In both, special Allison T40 turbine engines are used.

Although the Allison turbo-propeller has a better specific weight than most reciprocating engines, a system of external wings—the rotating blades of the propeller—has to be used to obtain a sufficient margin of thrust over weight for take off. Direct take-off is obtained, but not direct lift. The Convair Pogo is giving proof that the difficult problems of control and stability during the vertical take-off and during the transfer to the normal flight attitude have been solved. The first transfer was made at a height of 60 metres, but without closing the canopy or altering the pilot's seat from the vertical take-off position. Neither this aircraft nor the Lockheed Salmon can be fast because they use airscrews and suffer, to some extent, the disabilities of all aircraft with rotating-wing systems.

BOUNDARY-LAYER CONTROL

Sir Graham Sutton has pointed out that the aeroplane "has no exact counterpart in the natural flight of birds." Part of the discrepancy may be accounted for by the fact that birds use powered lift. Most birds would consider themselves professionally disgraced if they had to run like mad to take off and to land or if, when in the air, they were unable to rest on their outstretched wings. For take-off and for landing birds feed power into the air flow over their wings; they use forced circulation. Just when the aeroplane has shut down its engines prior to the touch down, most birds are pouring power into their wings. It is the "peripteral motion" described by Lanchester in the preface to his 1907 book on aerodynamics, the "motion generated around a bird's wing." One new approach to powered lift is concerned with feeding power into the air stream around the wing and making the wing work without either translational or rotary movement.

The first practical steps to hold down the boundary layer and so to encourage laminar flow over the wing were taken by Louis Constantin in 1913, by Dr. Thurston, and by Handley Page and Lachmann, whose wing slot was patented on February 19, 1918. The slots along the leading edge and along the flap persuade the air flow to cling to the surface up to bigger angles. This form of natural control of the boundary layer was carried to full development in the Handley Page Gugnunc which was second in the Guggenheim competition of 1929. It could land in 19 metres. Its speed range was nearly four to one. That is natural control of air flow. In its latest form it is seen in the Scottish Aviation Pioneer.

Birds use wing slots of a kind: but they also use wing flapping. The Soviet Kashuk glider seen in flight at Tushino last June has articulated wings and a recuperative flapping system worked by compressed air.

In the Crouch-Bolas experiment of 1930 and onwards, the air stream is accelerated over the wings and wing flaps by engine power, using the slipstream from the airscrew. The weight is held up partly by thrust and partly by aerofoil lift. The Crouch-Bolas Dragonfly twin-engined biplane was made to test this scheme and it showed a wide speed range—from 30 to 210 km. an hour; a ratio of 7 to 1. It could be landed in still air with a run of 8 metres.

Fig. 1 The Bell XV-3 convertible aircraft; after helicopter take-off the rotor masts tilt to a horizontal position to give propeller thrust for cruising.

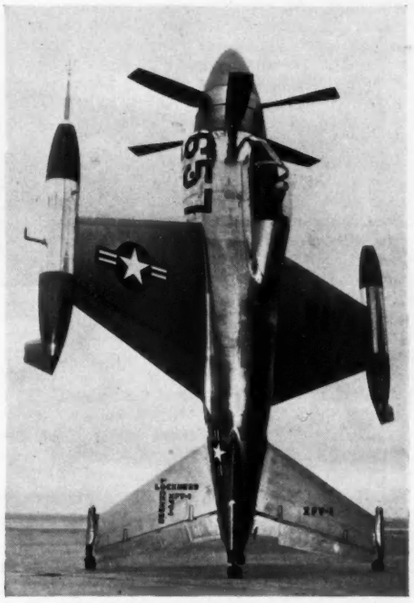


Fig. 2 The Lockheed Salmon vertical take-off aircraft.

Fig. 3 The Convair Pogo in level flight after transition from the vertical take-off.

The aircraft, which was built in America, was arranged so that the airscrew discs covered a big part of the wing span and thus exerted the slipstream effect to the fullest extent. At the time, the idea aroused less attention than it deserved. Other aircraft which tried the same system were the Chance-Vought V-173 and the Chance-Vought XF5U-1.

SUCKING AND BLOWING

Dr. A. A. Griffith designed a wing which used suction along the trailing edge. It was, in its original form, a fat wing with a cusp along the trailing edge where suction was applied. It was tried in Australia. A car engine was installed in a glider and used to generate suction. When towed by a Dakota the take-off time for the glider with suction on was halved. Keeble interpreted the results as meaning that, for the same fuel and same range, an all-wing air liner using suction would have 40 per cent. more load and be 40 per cent. faster.

Other methods of applying suction were proposed porous surfaces, and wing surfaces with

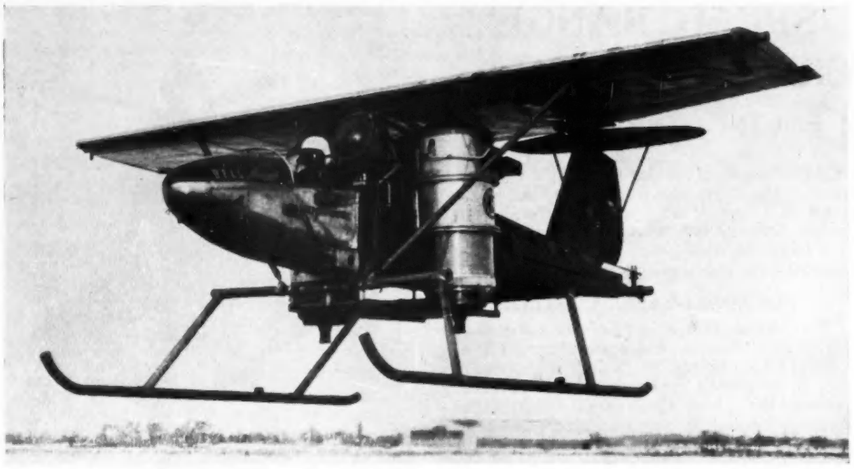


Fig. 4 The Bell VTOL aircraft, in which the jet engines rotate through 90 deg. for forward flight. Control is by compressed air jets supplied from a separate gas turbine.

spanwise slits. F. G. Miles suggested perforated metal surfaces. In 1936—the year in which a Fieseler Storch with suction wings was being tried in Germany—Miles began his experiment with his twin-engined BLS Peregrine. Air was drawn through the perforations by a modified cinema-ventilation fan driven through gears by a Ford car engine. The engine was not suited to the job, and with a gas turbine like a Turboméca the same wings would give better results. As it was, there was a 29-per cent. improvement in climb in return for an expenditure of 8 h.p. on suction. The use of blowing, as well as sucking, was proposed by Regenscheit in 1939, and during the war Arado, Messerschmitt and Dornier produced designs.

Still there were doubts in this country. The recent revival of interest is a sequel to the coming of the gas turbine, which is not only lowering the specific weight of aero-engines, but also substitutes a continuous fluid-flow process of power generation for an intermittent.

In 1951, the Arado system of blowing and sucking was installed in a Cessna 319A in the United States. A hydraulic motor works an axial fan which is buried in the wing between the sucking and blowing sections. Suction is used on the inner part, blowing on the outer part. In spite of the additional weight of the boundary-layer control system of 90 kg., take-off run is reduced from 90·4 metres to 58 metres, the rate of climb is steepened, and the landing run is shortened from 78·5 metres to 48·8 metres.

New work at the Royal Aircraft Establishment is even more promising. In a sleeve with porous surface, full-chord laminar flow was attained. Johnson reported that the drag reductions were "impressive" with a 70-per cent. reduction excluding induced drag.

In the Grumman F9F-A Panther ship-borne fighter there is a merging of boundary-layer control and gas turbine. This aircraft has the Attinello flap, which uses blowing. The air is ducted from the engine compressor. Take-off speed is reduced by 37 km. an hour with an additional load of 1,360 kg. The weight of the blowing apparatus is only 22·7 kg.

JET LIFT

All these methods of improving the low-speed powers of fixed-wing aircraft feed energy into the air stream. But there is another, even more direct, kind of powered lift—jet lift. The most representative examples which have so far flown are the Rolls-Royce thrust-measuring rig and the Bell VTOL (Fig. 4). Ryan are building a direct-lift machine but it has not yet flown.

The "flying bedstead" is mainly the work—again—of Dr. Griffith. It depends upon its engines giving a thrust greater than its laden weight. Its control and stability are secured—as they must be with an aircraft that can hover—by a completely different means from that employed in an aeroplane. Jets of air bled from the engine compressors are used at four balancing points. The system was developed by Rolls-Royce in collaboration with the Royal Aircraft Establishment.

The Bell VTOL differs from the "flying bedstead" mainly in that it uses a separate gas turbine for supplying compressed air for the control jets, and in that the two main lifting engines can be rotated in flight and used for propulsion, lift then being obtained from the small fixed wings.

Both these aircraft use jet deflection, first successfully demonstrated by the French nationalised company of SNECMA at the Paris *Salon* at Le Bourget in 1953. In this instance, it was used for braking after landing. The jet deflector designed by the National Gas Turbine Establishment can contribute to the lift.

A Meteor with this deflector was prepared by Westland Aircraft Limited—a company which has experimented with blowing over flaps in swept-wing aircraft. The modified Meteor first flew in May, 1954, and the pilot reported a reduction of 20 per cent. in approach and stalling speeds with jet deflection.

Other methods for improving the speed range include the trapped vortex for maintaining laminar flow, variable sweep-back wings and tail surfaces, and the Rolls-Royce conception of a wing which is in itself an air intake for an "air consuming propulsion system." The American Marquardt company has produced a small wing which is a ram jet, for helicopter rotors.

Integration of the engine and wing system is the aim of the Zborowski coleopter, free flying trials of a scale model of which, powered by a pulse jet, have been made successfully by SNECMA. The engine is accommodated in the centre of an annulus behind the cabin, and this annulus is itself either a ram jet or a ducted fan in flight (Fig. 5). The coleopter is the logical outcome of experiments that have been going on in France since 1907, when René Lorin proposed his *tuyère propulsive*. The latest propulsive duct, to René Leduc's designs—which is to fly soon—resembles the coleopter in that there is a central turbojet surrounded by a tube which gives an induced flow for take off and landing, and which, in flight, becomes a ram jet.

Quite recently information has been released of the first man-carrying ducted fan. Built for the United States Navy, the new flying platform uses shifts in the body weight of the pilot as a means of control, as over 60 years ago Lilienthal and then Pilcher used body movements to control their gliders. Tethered flights with the ducted fan were made in 1952 by the National Advisory Committee for Aeronautics.

Blown flaps are proving successful; direct jet lift has been shown to be practicable; ducted fans and ram jets have been flown successfully. When these things are appropriately combined we may perhaps arrive at an air vehicle capable of cruising at speeds around the speed of sound, yet also capable of taking off from an aerodrome no larger than the roof of a railway station.

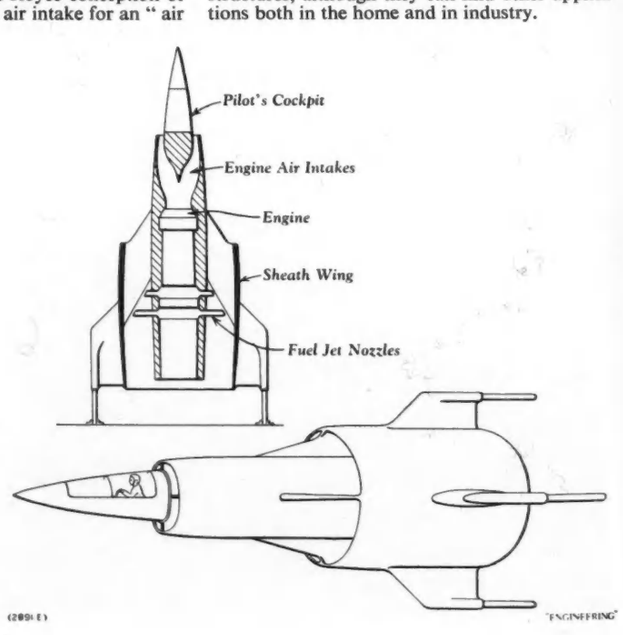


Fig. 5 In the coleopter, the engine is in the centre of an annulus behind the cabin. The annulus itself forms either a ram jet or a ducted fan in flight.

(2891 E) "ENGINEERING"

★ ★ ★

ZINC-RICH PAINTS

Binders Added Just Prior to Use

Paints rich in zinc are blended to combat corrosion, but due to the high zinc concentration, sometimes as much as 95 per cent., there are difficulties in finding suitable binders and in methods of storage. Durham Chemicals, Limited, Birtley, Co. Durham, claim to have evolved satisfactory formulations using chlorinated rubber and polystyrene binders, with a small amount of plasticiser to ensure the right degree of elasticity in the film. Storage difficulties have been obviated by marketing these paints on a two-pack basis for mixing prior to use. The paints are usually applied by brush, but can be applied by dipping or spraying. Their normal use is for the priming of iron and steelwork structures, although they can find other applications both in the home and in industry.

100-MVA REACTOR CONTROLLED BY DIRECT CURRENT

CONSTRUCTION AND APPLICATION FOR MACHINE TESTING

*By F. J. Fisher and E. Friedlander**

Works tests on electrical machines of above a certain output cannot be carried out at their rated load because the input power is not available and the output cannot be consumed. With a few exceptions, therefore, the works check on the performance of a new machine has been confined to short-circuit and open-circuit tests, backed up by occasional reactive power or back-to-back tests.

The rapid development of large machines, together with the changes that are now taking place in the cooling circuit arrangements have, however, reduced the value of earlier experience. The maximum temperatures now reached in certain parts of a machine are due to a complicated flow of heat in which the stator losses contribute to the temperature distribution in the rotor and vice versa; also, the iron losses contribute to the temperature of the copper, and the current loading to the temperature of the iron. In addition, there are a number of problems, particularly those arising from the sources and distribution of the stray losses and the characteristic machine constants, which are difficult to determine with the desirable accuracy if only short-circuit and open-circuit tests are made.

The expense of providing improved testing facilities is therefore justified, since they would provide a more reliable picture of the ultimate output limits of a given machine, and thus prepare the way towards a more economical design.

SOME ESSENTIAL REQUIREMENTS

A reactive loading equipment suitable for these purposes should clearly define the relationship between the voltage, current and losses of the testing device; provide easy, and preferably stepless, control of the reactive power over the range of voltages at which the tests are to be carried out;† and ensure freedom from wave distortion due to the reactive load. These requirements have led to the design of a direct-current controllable reactor with a rated output of 100 MVA for voltages between 6·6 and 22 kV, with some margin for higher voltages and overload capacity. Apart from satisfying the above requirements, it has been possible to build the reactor so that a definite wave distortion can be produced for studying the behaviour of machines under conditions of non-sinusoidal current loading.

A direct-current saturated reactor is suitable for giving easy reactive power control, such as may be effected by varying the saturation of the magnetic material. It is necessary, however, to pay particular attention to undistorted current consumption with sinusoidal voltage, owing to the extremely high iron saturation which must be adopted if a reactor of the size described is to be economical. This problem was solved more than 20 years ago when a test model was demonstrated by one of the authors;‡ while a more elaborate experiment made at the Witton works of the General Electric Company, Witton, in 1946 supported the view that the saturation harmonics could be eliminated to the required extent.

The basic idea of this early design, namely, to displace the phase fluxes by 30 deg. with respect to each other in two equally-saturated core groups, has much in common with that compensation of harmonics which takes place in polyphase rectifier equipment. There are many feasible winding arrangements, differing mainly in the methods of producing the phase shift and of compensating the various harmonics which are permitted to appear internally either in the currents or the fluxes, by adding oppositely distorted voltages or oppositely distorted currents when the relevant windings are connected in series or parallel.

CONSTRUCTION

The winding schemes that may be adopted vary from that in which the fluxes are sinusoidal and the ampere-turn pressure is most distorted, to that in which the ampere-turn pressure becomes practically sinusoidal and the flux wave most distorted. All schemes involve complete compensation of the harmonics up to and including the ninth. The eleventh and thirteenth current harmonics, however, become gradually worse and their total root-mean-square value may theoretically reach about 12 per cent. (stepped wave) when all the windings are connected in series.

Sinusoidal fluxes are obtained when all the core groups are connected in parallel by having a short-circuited mesh winding on all the groups, preferably even if there is no ferromagnetic path for the third harmonic flux between the yokes. This is consistent with normal three-phase transformer practice. The chosen design promised to give minimum current distortion and lowest eddy-current and direct-current losses. At the same time, it afforded maximum freedom for variations in the winding connections, giving a wide range of voltages and currents with good output.

A three-phase reactor of the type described requires twelve wound cores, the arrangement chosen consisting of two identical units each with a six-limb core. Each of the units therefore has a rating half that of the total reactor. A six-limb core is relatively easy to construct and the sub-division of the reactor into two units, which is necessary to obtain the desirable compensation of the harmonics, reduces the weight and size of the components and thus simplifies manufacture.

The general arrangement of each six-limb core is shown in Fig. 1. In large reactors of the saturated type it is necessary to employ extremely high flux densities in order to reduce the weight of the iron to an economical figure, and this was the dominant factor in the core design. Because of the very high magnetic pressures involved, it was desirable to limit the amount of magnetic flux in air passing between the outside of the core and the alternating-current coils, and rectangular section limbs were therefore used. This has the additional advantage of permitting simple clamping with the minimum number of through bolts. At the same time the absence of any risk of short-circuit stresses made it permissible to forgo the advantages of circular coils with their inherent mechanical strength.

The saturated volume of iron was confined entirely to the core limbs by using substantially oversize yokes. Apart from reducing the leakage flux, this arrangement ensured that the three phases were magnetically symmetrical although the lengths of the individual flux paths through the cores differ. Since the yokes must carry a varying amount of direct-current flux, the sectional area of the yoke must be suitably proportioned. A practical compromise with theory was achieved by stepping the yoke to give different effective depths. Each core limb is divided into two parts by a cooling duct which also serves as a passage-way for the through bolts. This will be seen from Fig. 1.

ELECTRIC CIRCUIT

The diagram of the parallel zig-zag-star connection normally chosen is given in Fig. 2. This connection is used for 6·6 kV, 11 kV and 15-kV ratings up to a maximum reactor output of 100 MVAr. Other connections are available for special test purposes. The turn ratio of the windings *a* and *b* is chosen so that the magnetic flux in each unit is displaced 15 deg. with respect to that which would be obtained with a simple star connection. Each of the two units has the same internal connections, but the line connections to the three-phase alternating-current supply are reversed for one unit to obtain the desired 30 deg. displacement between the magnetic fluxes of the two.

A particular advantage of the 15 deg. zig-

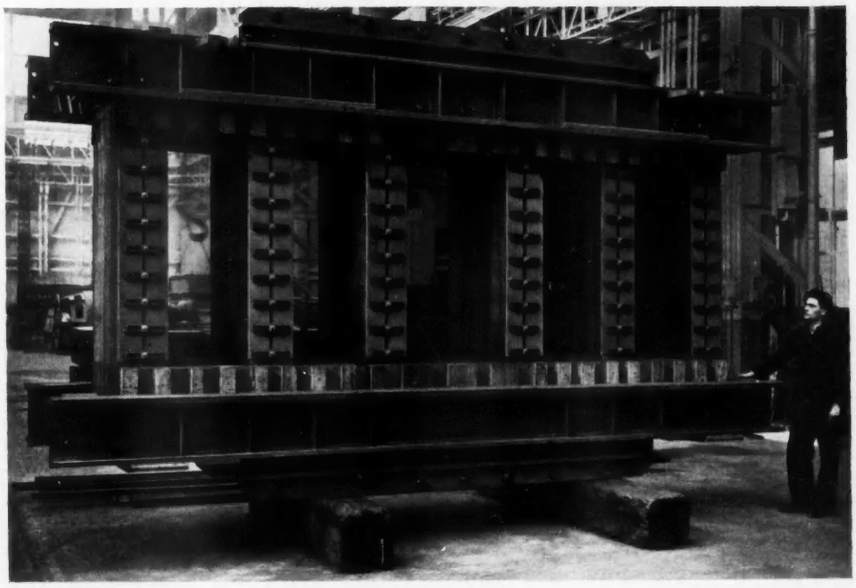


Fig. 1 General arrangement of six-limb core of 100-MVA three-phase reactor designed primarily for works tests on electrical machines.

* The authors are with the General Electric Company, Limited.

† This is particularly important for obtaining complete zero power factor characteristics in the determination of machine constants.

‡ The unpublished paper and the demonstration are referred to in *Elektrotechnische Zeitschrift*, vol. 59, pages 1020 and 1093 (1932).

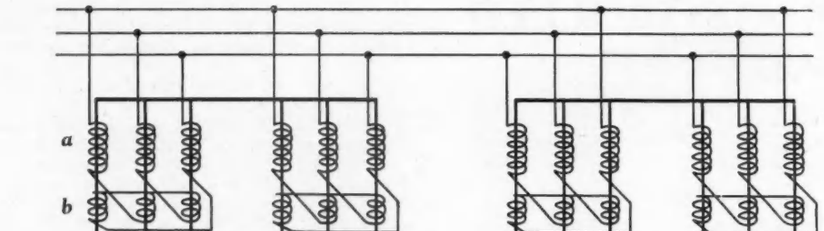


Fig. 2 Diagram of parallel zig-zag-star connection for reactor.

zag winding is that it leaves open the choice between external star or mesh connection without restricting the compensation of harmonics. With the additional freedom to connect the windings of both core groups on each reactor in series or in parallel, a voltage range of over $(2 \times \sqrt{3})$ to 1 is covered with the same maximum flux density merely by changing the terminal connections.

With the arrangement shown the even-harmonic currents which occur upon the application of direct-current saturation, will circulate internally within the alternating current windings of each unit, and the fifth and seventh harmonic currents will flow only between the two units and not into the alternating-current supply lines. Each unit is provided with two delta-connected tertiary windings *c* to permit circulation of the third harmonic currents. The rating of the tertiary winding is determined by the maximum third harmonic content under the worst conditions of saturation. Provision is also made for connecting the two tertiary windings of each unit in series, so that the effect of this connection upon the transient response of the reactor can be examined.

Each unit has two direct-current coils *d* which are series connected, and each of these coils embraces the three alternating-current limbs of the core. The advantage of this arrangement is that it considerably reduces the voltage stresses in the direct-current coils, since the induced alternating-current voltage, due to the fundamental-frequency flux component, is zero. Fig. 3 shows one reactor unit complete with coils and fitted with a lifting beam.

MECHANICAL ARRANGEMENT

In the mechanical design of the reactor the main consideration is to achieve a satisfactory arrangement which will not give rise to undue heating of the clamping structure due to leakage flux.

As already stated, the effective volume of iron in the reactor operates at extreme saturation values. At such high values of direct-current magnetisation the reactor behaves sensibly as if there were no magnetic core. The number of bolts passing through the saturated iron is a minimum, the bolts themselves being of non-ferrous material. The iron clamps on the limbs are designed to have a minimum mass of metal and consist of hollow rectangles cast in non-magnetic steel with suitable strengthening ribs. The main yoke clamps are spaced from the yoke by impregnated specially-treated hardwood blocks and are set back from the alternating-current windings by a distance which is determined by the maximum magnetic pressures involved. Apart from satisfying the foregoing requirements, it was found possible to use simple clamps since no high short-circuit stresses are involved.

Each reactor unit is mounted in an oil-filled tank complete with conservator and Buchholz relay, as well as the usual fittings appropriate to a large outdoor transformer including oil and winding temperature indicators. Fig. 4 shows the finished reactors installed in the outdoor compound of the test plant. The total weight of each reactor with oil, but excluding coolers, is 133 tons.

Each unit is provided with a separate oil cooler of the forced-oil, air-blast type, which is arranged to dissipate the full losses of the associated reactor. The coolers are mounted adjacent to the reactors, as also shown in Fig. 4.

The direct-current supply for reactor magnetisation is obtained from a 500-kW rectifier, which is supplied through a step-down transformer of the hermetically-sealed, Class B insulated, air-cooled outdoor type. Smooth variation of the direct-current is obtained by means of grid control. The kind of operation required for the present purpose made it undesirable to provide for high-speed static phase-shifting equipment. The grid control is therefore effected by means of a normal phase-shifting transformer, the secondary winding of which is accommodated in the rotor and operated by a small motor. This winding feeds the grids of the rectifier through a square wave transformer of the type fitted to all large grid-controlled General Electric mercury-arc rectifiers.

LOSSES REQUIREMENTS

It is essential that the losses of a loading reactor, which must be fed from the alternator being tested and correspondingly from its test, bed driving motor, should be low. The direct-current controlled reactor is, from this point of view, very favourable. The losses to be supplied by the test motor, that is, the alternating-current losses, are nearly a constant proportion below 1 per cent. of the absolute kVAr output. It is obvious that, except in the low-voltage low-power range, the losses do not vary very much whether the same output is produced with low voltage and high direct-current excitation or vice versa.

Fig. 5 shows the alternating-current losses after subtraction of the I^2R losses. The results are plotted as a function of the applied voltage for varying currents. In an ordinary transformer these losses would, of course, represent only the iron and stray losses and would vary little with the current. In a reactor with parallel-connected windings the dominating contribution is the losses due to the circulating harmonics. The iron losses, which cannot be separated out without careful analysis of the individual currents and of the eddy currents which increase the effective alternating-current resistance of the windings, are of relatively little importance. They are lower than normal for the same alternating-current flux density because, with a sinusoidal flux, the eddy-current losses are independent of the direct-current saturation, and the hysteresis losses decrease appreciably due to the hysteresis loop collapsing when high saturation is reached. This also explains the large drop in the losses with increasing direct-current excitation in the low-power range.

The losses in the direct-current windings are normally less than $\frac{1}{4}$ of 1 per cent. of the rated kVAr output and may be calculated from the winding resistance of 1·05 ohm at 90 deg. C. for any condition for which the alternating-current losses are given in Fig. 5.

COMPENSATION OF HARMONICS

As an example of the precision with which the compensation of harmonics was accomplished with a nominal load of 100 MVA, it may be mentioned that the voltage was roughly distorted by a percentage not exceeding $1\frac{1}{2}$ per cent. for the eleventh and thirteenth harmonics, other harmonics being practically absent. An eleventh current-harmonic of 1 per cent. will produce a voltage distortion at the terminals of an alternator of the same order of magnitude, since an alternator reactance of the order of 9 per cent. will correspond to an impedance of 100 per cent. with reference to the eleventh harmonic. The effect of harmonics of this order on the performance of the machine is negligible. Naturally the increased alternating-current resistance of the alternator windings for the higher harmonics must be taken into account but, in view of the quadratic relationship between copper losses and currrents, the error produced by the residual harmonics is less than $\frac{1}{1000}$ of the normal copper losses, i.e. well within the limits of metering accuracy. The equipment is, however, so designed that by a simple reconnection at the reactor terminals a deliberate wave distortion can be produced without a reduction of output.

VOLTAGE AND CURRENT CHARACTERISTICS

With constant alternating voltage, the alternating current rises almost precisely in proportion to the direct-current excitation. For

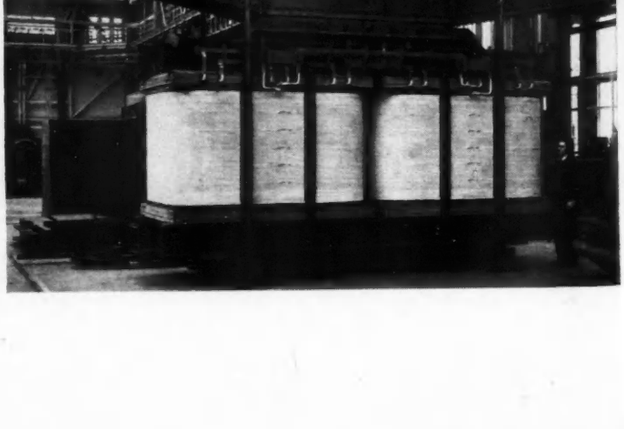


Fig. 3 A reactor unit complete with coils and lifting beam.

large reactors the minimum alternating current at zero direct-current excitation is particularly low relative to the full load current if the alternating-current saturation is chosen in accordance with normal transformer practice. This corresponds to the very low proportion of magnetising current of large transformers. Hence at 12 kV the 100-MVA reactor in external star connection has a minimum current at zero direct-current excitation of not more than 0·36 per cent. of its rated current, thus giving a current control range of about 300 to 1 without taking the available overload capacity into account. The relation between the alternating current and the alternating voltage at constant direct-current excitation for this case is shown in Fig. 6.

When using an external mesh connection, however, the reduced direct and phase currents required to give a certain alternating-current output were found to provide an appreciable margin for overload. The reactor has actually taken more than 100 MVAr on a heat run of one of the alternators under test without exceeding its safe running temperature.

NOISE LEVEL

The question arises as to whether the very high saturation which occurs in reactors of this size will cause noise to reach a disturbing level. No precise measurements have been taken so far, but the observations available indicate that direct-current saturation by itself does not contribute to greater noise, even if the instantaneous saturation values reached increase very appreciably. In other words, when the reactor is operated under the conditions leading to the characteristics in the range shown in Fig. 6, the noise level is comparable with that of a transformer of corresponding size. If, however, the alternating-current saturation is increased to such an extent that an appreciable kVAr ouput is obtainable even without direct current, the humming noise ceases to be negligible, although it is not comparable with the noise of a machine running in the close vicinity. It will, therefore, be necessary to pay attention to acoustic shielding only in those cases where advantage is to be taken of the alternating-current saturation characteristics.

SPEED OF RESPONSE

The actual speed of response of reactors of this size has not yet been measured on account of experimental difficulties. For a direct demonstration of transients, an alternating-current voltage supply would be required which remains rigidly constant in spite of a varying and heavy reactive load. This was not available for the reactive power of the magnitude involved. In addition, the method of control adopted will not take advantage of the available speed of response of the reactor. In view of the other fields of application it may, however, be of interest to give the figure which has been derived theoretically from the change of magnetic energy to be controlled by the direct-current input. It was found that the time constant with which the flux may be expected to obey any varying direct-current excitation with constant alternating-current voltage will be less than about 0·7 seconds and could be further reduced by increased direct-current power consumption. This shows that if advantage can be taken of a controllable reactor for purposes of reactive power control in networks, it is bound to be superior in speed of response to that which can be achieved, say, with synchronous condensers. The physical reason for this advantage is the relatively small magnetic energy content which must be varied by the direct-current excitation, due to the inherent function of a direct-current saturable reactor. By comparison, the changes in magnetic energy necessary for changing the reactive power of a synchronous condenser are linked with the basic magnetic energy stored in the air gap of any synchronous machine. This is much greater than the variation of the stored energy actually required for a change of reactive output, and leads to a more sluggish response for the same ratio of excitation power to MVAr output.

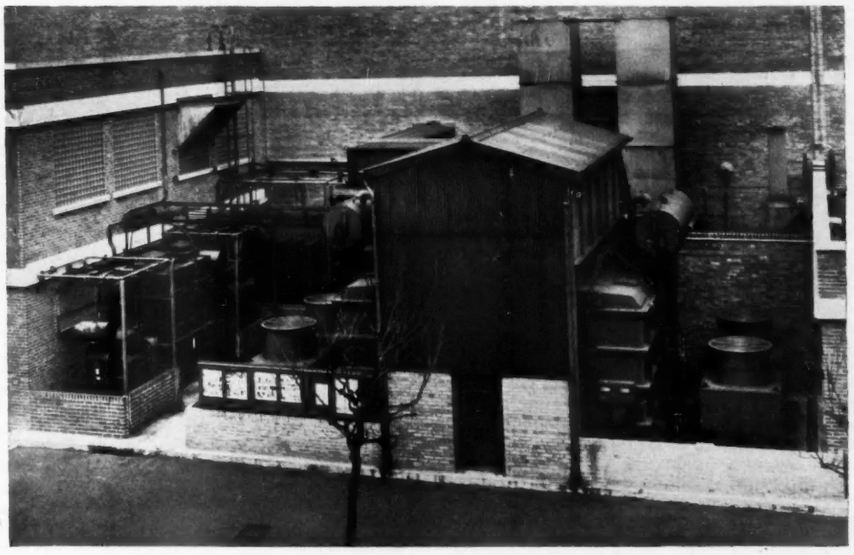


Fig. 4 Oil-cooled reactor and coolers installed in outdoor compound of test plant at Witton.

OTHER FIELDS OF APPLICATION

The type of controllable reactor described should be suitable for a number of different applications. For instance during periods of low power many networks suffer from excessive capacitive load which may interfere with the excitation stability of the generators, with the voltage level at which the network can be held and with the number of machines which must be kept in operation for reasons of excitation stability. The capacitive load due to a large cable system, or to long transmission lines which cannot be taken out of service at times of limited load, may cause avoidable losses in insufficiently loaded machines. Where, therefore, a large concentration of capacitive power may become dangerous under certain conditions of network disturbances, the inherent protection due to the presence of highly-saturated iron is particularly valuable.

The usefulness of reactors of this type may also become more obvious with increasing use of large power factor correcting capacitors. The direct-current controlled reactor will be suitable to fill a gap in the stepless and static control of large capacitor banks, and will alleviate switching problems by suitable interlinkage between reactor control and step switching. The combination of a static capacitor with a direct-current controlled reactor has the essential features of a synchronous condenser combined with all the advantages of static equipment, such as lower overall losses, easy outdoor installation and a minimum of maintenance.

In theory, alternating-current power transmission is stable over an unlimited distance if the stabilising voltage control satisfies a very simple condition: at no point on the line must the rate of change of voltage with varying

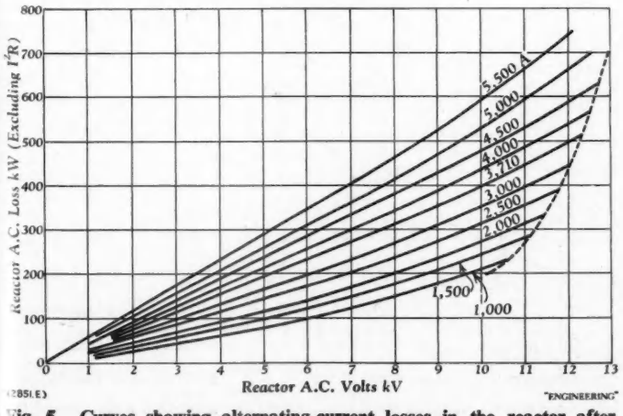


Fig. 5 Curves showing alternating-current losses in the reactor after the subtraction of the I²R losses.

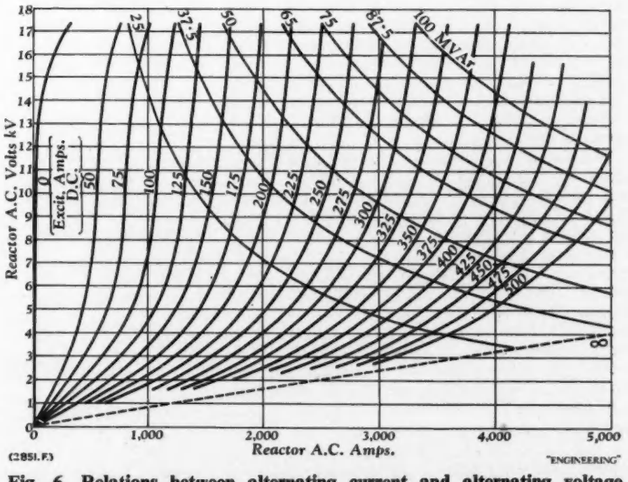


Fig. 6 Relations between alternating current and alternating voltage with constant direct-current excitation with minimum magnetising current.

reactive power due to varying load be so great that the linear extrapolation to no-load would give more than 33 per cent. overvoltage. Provided there is an excess of capacitive power available, the stabilisation of long distance alternating-current transmission may therefore be accomplished by automatic voltage control using controllable reactors. This may be particularly advantageous on long lines carrying limited power, such as may be in use in countries where the development of electrical power distribution is in progress.

Further applications may include the control of current distribution in complex interlinked networks as a self-adjusting alternative to the use of quadrature booster transformers. The direct-current controlled reactor may, in such cases, serve automatically to limit the current. It may also assist in solving the problem of controlling the exchange of power between large networks through relatively weak links by reducing the otherwise excessively stringent conditions for speed and precision of load frequency control on either side of the link.

A number of problems for which controllable reactors have been used extensively in the past for low and limited power may now also include those in the range of hundreds of megawatts. Such problems include power control of large heater installations and rectifiers for electrolytic plants, where the controllable reactor may help to solve switching problems in conjunction with on-load tap-changing transformers.

CONCLUSION

The direct-current controlled test reactor at the Witton Works of the General Electric Company, Limited, has not only contributed to a useful improvement of the testing facilities for the largest alternators at present manufactured, but also appears to be valuable as a prototype of the giant transductor which is expected to have a wide field of other applications in the future. The experience gained with this prototype may well establish the practical importance of this inherently reliable type of equipment, which can be built for virtually any voltage, current and reactive power.

★ ★ ★

MEASUREMENT OF FLUID LEVEL IN WELLS

A liquid-level gauge designed for use in oil wells is described in a report issued by the United States Bureau of Mines.* The instrument is 1¼ in. in diameter and about 6 ft. long, and can be operated through 2-in. tubing. It is lowered into the borehole or well and the depth of the assembly is shown on a wire-line depth indicator. Inside the instrument is a float, and when this touches the liquid surface and starts to move upwards, indication is given electrically (via a circuit carried in the supporting cable) on a control panel at the surface. As the float moves up, the movement is communicated to a sliding contact which bears on a variable resistor. The movement of the float is recorded at the surface, and thus changes in liquid level can be detected immediately.

The accuracy of measurement is limited by the accuracy of the wire-line depth indicator, but it is sensitive to changes in liquid level of ½ in. The float and the sliding contact are connected by a float arm, and since the instrument is hermetically sealed at the top, the air or gas in the upper part of the instrument must be compressed before liquid can reach the electrical circuits. In practice, this means that if the air or gas in the well is at atmospheric pressure the instrument must be submerged 30 ft. below the liquid level before liquid reaches the electrical circuits. By the use of auxiliary equipment the instrument can be made to indicate and record moving liquid levels automatically.

* Report of Investigations 5060, "Bureau of Mines Liquid-level gauge." Obtainable from Bureau of Mines, Publications Distribution Section, 4800 Forbes-street, Pittsburgh 13, Pa., U.S.A.

Fig. 1 The turbo-alternator can be seen under the tent, mounted on its tubular steel frame. A Diesel set of the same output is shown in the background.

POWER FOR EMERGENCIES

50-kVA Set Driven by Gas-turbine

Lightweight plant for supplying electric power at remote sites has been developed by Petbow Limited, Sandwich, Kent, and was briefly described in the issue of ENGINEERING for November 26, 1954, vol. 178, page 705. The generating set consists of a Rover gas-turbine, weighing about 120 lb., with an output of 60 h.p., and a three-phase, 50-cycle, 440-volt alternator made by the Macfarlane Engineering Company, Limited, Netherlee-road, Cathcart, Glasgow, S.4. Alternative versions are available for 60 cycles or direct current, and the maximum output in temperate climates is 50 kVA at 0·8 power factor; this figure is reduced at higher ambient temperatures due to the turbine characteristics.

The great advantage of this turbo-alternator set is the very high power-to-weight ratio. The set weighs 1,200 lb., which compares very favourably with a Diesel set of the same capacity. In the accompanying illustration the turbo-alternator can be seen under the tent covering, and a Diesel set of the same capacity is behind and to the left of the tent. The dark object on the right of the turbo-alternator set is a metering device, and is not normally used with the set. Its light weight and robust construction make the set very suitable for use in emergencies as it can be parachuted from transport 'planes. Emergencies in civil life and the exigencies of military campaigns are both occasions when the set can be used to good effect. Its main disadvantage is the high fuel consumption; as the accompanying performance figures show, the consumption at 10 deg. C. ambient temperature is 2 pints per kilowatt per hour, or 10 gallons per hour for an output of 40 kW. The tank incorporated into the set illustrated contains 20 gallons, enough fuel for only two hours. In spite of this, however, there is no doubt that for emergency and military uses the set will be invaluable.

The alternator is driven from a reduction shaft on the engine through a special coupling; while specially designed for turbine drive, it is based on the standard Magnicon range designed and built by Macfarlane. It is self-regulating within ± 2 per cent. of voltage at all rated loads and power factors, without the need of a separate automatic voltage regulator. Speed as well as voltage is closely controlled, and the engine governor maintains the output within one cycle of the nominal 50 cycles between no load and full load. The power unit is mounted inside a tubular steel framework which also supports the 20-gallon fuel tank and a control panel carrying voltmeter, frequency meter, main switch, fuses, and overload warning lamps.

★ ★ ★

TELEVISION IN THE ISLE OF MAN

The British Broadcasting Corporation have now made plans for the development of television and sound broadcasting in the Isle of Man, after consultation with the Lieutenant-Governor and his Advisory Committee.

At present the temporary television transmitter at Carnane, near Douglas, is giving a satisfactory service to about 60 per cent. of the population. This service will be still further improved when the station at Divis, near Belfast, is opened shortly, while transmission of reasonable quality is already received direct from Holme Moss.

Meanwhile a search for a suitable site for a permanent television transmitter to cover the whole island has been made; and it has become obvious that the summit of Snae Fell would be the most suitable. The Ministry of Transport and Civil Aviation was not, however, prepared to permit such a station to be erected unless it could be demonstrated that no interference would be caused to the Ministry's transmitting and receiving station which is already operating on the mountain. Moreover, the right was reserved to close down the transmitter temporarily should the safety of aircraft be endangered. Nevertheless, the Corporation consider that the proposal to use this site should be pursued and the necessary tests will therefore be carried out early in 1956.

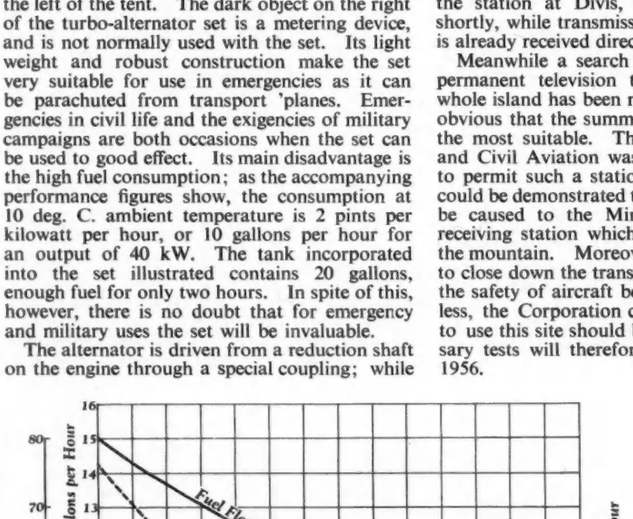


Fig. 2 Performance and fuel consumption curves related to varying temperature show that output decreases with increasing ambient temperature.

All movements of the Simon hydraulic platform may be controlled by the operator, who can thus place himself in any position necessary for the execution of his work.

VERSATILE OVERHEAD PLATFORM

Cradle with Three-Dimensional Mobility

"The apple tree is famous for its part in one historic discovery," said Sir Patrick Hamilton, chairman of Thomas Adshead and Son, Limited, at a demonstration of the Simon hydraulic platform, "and now it has borne fruit of a different kind." Originally designed for apple picking, the Simon hydraulic platform provides a safe and flexible support for a man and his tools in any overhead position within the range of the equipment. It consists essentially of a turntable carrying a double hinged arm, at the outer end of which a cradle is fitted. All movements can be controlled from the platform, which is automatically maintained in a horizontal position.

Some indication of the flexibility of the unit is given in the accompanying illustration, which shows it mounted on a motor vehicle. Among its applications are: repair and maintenance of street-lighting systems, telephone wires and electric-power lines; external work on ships' hulls; assembly, inspection and servicing of aircraft; fire-fighting and rescue; quarry drilling; building construction; and a variety of miscellaneous duties in factories and workshops. It is very much safer and quicker to use than the scaffolding and ladders at present employed for many of these purposes.

HYDRAULIC OPERATION

The equipment is entirely hydraulic in operation, and a small internal-combustion engine drives the pump which supplies hydraulic pressure. There is no power supply or other connection with the chassis on which the turntable is mounted, and the main working parts are self-lubricating. Movements are controlled from the platform by means of pedals for raising and lowering, and a knee-operated control for rotation, so that the operator's hands are free for his work. Duplicate controls are provided on the turntable, and the movements can be effected smoothly and accurately. Telephone communication between platform and driver's cab may be fitted if required.

To ensure stability, spring lock-outs are fitted to prevent movement of the rear springs of the vehicle while the platform is in use, and strong outrigger jacks are also provided at the rear and sides. The turntable is self-locking as a precaution against rotation when the vehicle is standing on a gradient, and the machine is built to lift two men and their tools with a generous safety margin. Moreover, all hydraulic lines are of seamless steel tubing, but should a line break, descent is limited to a safe speed. If the pump or motor fails, the platform remains in position until lowered by the operator, and automatic cut-outs stop the motion of the platform if it moves beyond set limits or descends on a solid obstruction.

Mounted on a normal chassis, the unit offers a maximum platform height of 36 ft. above ground, so that the operator's working height is more than 40 ft. The greatest horizontal extension of the platform gives a working radius of 25 ft. from the centre of the turntable, which is capable of continuous rotation in either direction. The equipment can be easily mounted on any chassis of 3 tons or over, with twin rear wheels, or alternatively on suitable types of road trailer, railway truck or pontoon.

The Simon hydraulic platform has been developed by Thomas Adshead and Son, Limited, Angel-street, Dudley, Worcs., from an original Canadian design and is made by Simon Hydraulic Machinery, a branch of that company. Thomas Adshead and Son is a subsidiary of the Simon Engineering Group, which is responsible for distribution of the new machine in all parts of the world except North America, where the production licence is held by a Kansas firm. The platform has been demonstrated at the Birmingham section of the British Industries Fair, Castle Bromwich.

* * *

MOBILE FREQUENCY CHANGERS FOR H.M. DOCKYARDS

The adoption by the Admiralty of a frequency of 60 for the alternating-current systems on H.M. ships has necessitated the provision of mobile frequency changers in the Royal Dockyards at home and abroad, so that supplies can be drawn from the 50-cycle mains while the vessel is in port. Ten units comprising a motor-alternator set with its control gear have been supplied for this purpose by the General Electric Company, Limited, Kingsway, London, W.C.2. The equipment, as is shown in the accompanying illustration, has been mounted on four-wheel trailers of 7½ tons capacity manufactured by the Eagle Engineering Company.

DETAILS OF EQUIPMENT

The motor-alternator set, which is mounted on a combination bedplate, consists of a 350-h.p. 400/440, 50-cycle squirrel-cage induction motor, which is directly coupled to a 300-kVA 0·8 power factor, 460-volt, 60-cycle three-phase revolving field type alternator and its flange-mounted exciter, the speed being 735 r.p.m. Both the motor and the alternator are pipe-ventilated, the air ducts leading upwards to the roof on which the inlet filters and outlet louvres are mounted.

The control equipment is housed in two sheet-steel cubicles at the rear of the trailer. One of these contains the automatic star-delta starter for the motor and a triple-pole hand-operated isolating switch, which is fully interlocked. In the other is housed a triple-pole oil circuit-breaker with a rupturing capacity of 10 MVA at 440 volts for controlling the 60-cycle output from the alternator. There are also hand-operated and automatic voltage regulators, the latter being of the carbon-pile type and designed to maintain any voltage between 450 and 470 volts to within $\pm$ 1 per cent.

Both the incoming and outgoing connections are brought into the trailer through clamps fixed to the underside of the deck. The 50-cycle cables terminate in a connection box mounted on the starter panel, while the 60-cycle leads are taken to a terminal box on the side of the output control cubicle. For purposes of safety the lid of this box is interlocked with the oil circuit-breaker. Non-hygroscopic materials are used throughout in the construction of the electrical apparatus.

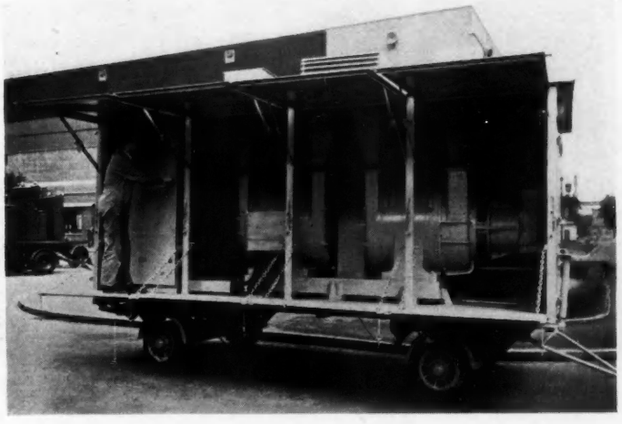
All parts of the equipment have been rendered accessible by providing the steel canopy with two doors at the front and two at the rear. In addition, each side of the canopy is divided into four sections, the upper half of which is arranged to hinge upwards and the lower half downwards, as shown in the illustration. A jack is fitted at each corner and is hinged upwards when not in use.

* * *

GRAIN BLOWER ADAPTED FOR DRYING

After hearing of a farmer who had used one of their grain blowers to dry grain, Scottish Mechanical Light Industries, Limited, Scotmec Works, Ayr, carried out experiments to produce a simple attachment to convert the blower to a drier. The result was a drying hood which is bolted on to the blower with built-in 420 cc. B.S.A. engine. The hood collects the air drawn over the air-cooled engine and the hot exhaust pipe, and leads it into the blower-inlet. The hood is fitted with a regulating slide so that the temperature of the drying air can be set as required. By opening the slide cold air is admitted from the atmosphere to mix with the hot air drawn from the engine. When using the blower for grain-conveying, the regulating slide is fully opened; it is not necessary to remove the drying hood.

The blower with built-in 420 cc. engine and drying hood will deliver air heated to 20 deg. F. above atmospheric temperature (dependent on ambient temperature) at a rate of 2,000 cub. ft. per minute at 5 to 6 in. water gauge, or 1,800 cub. ft. per minute at 7 in. water gauge. This should be sufficient to dry two bins 10 ft. in diameter, each filled with grain to a depth of 10 ft.



One of the mobile frequency changers designed to provide a 60-cycle shore-to-ship supply in H.M. Dockyards.

The " Staffa-Bruneri " mobile excavator powered by a Diesel engine driving through a Plessey hydraulic pump.

LORRY-MOUNTED EXCAVATOR

Convertible Hydraulic Machine

The " Staffa-Bruneri " excavator shown in the illustration above is powered by a Diesel engine connected to a Plessey hydraulic pump. This arrangement has enabled the makers to take advantage of using only hydraulic controls. Although shown here fitted with a " crowd " shovel, other equipment is available to convert the machine into a " backacter " for trenching or, with a grab bucket, for stockpiling; alternatively, a crane attachment can be substituted for the bucket equipment. Mounted on its own turntable which gives it full-circle slewing, the machine is suitable for use on an articulated trailer or on a six-wheel chassis of the type shown in the illustration. The machines are available in the United Kingdom from Chamberlain Industries Limited, Staffa-road, Leyton, London, E.10.

Typical figures claimed for the hourly performance of the Staffa excavator are, using a standard 10-cub. ft. bucket, 40 to 55 cub. yd. of straight excavation, 25 to 35 cub. yd. of trenching or 65 to 85 cub. yd. of loading from a loose stockpile. The maximum reach of the machine as an excavator is 14 ft. 9 in. or, as a trencher, 16 ft. 5 in. The maximum height of the discharge is 14 ft. For normal excavation work the greatest depth of cut is 3 ft., but equipped as a trencher this figure is increased to 6 ft.

POWER PLANT FOR A CEMENT FACTORY

TEMPORARY INSTALLATION AT CHURK, INDIA

To exploit the valuable mineral resources in the Mirzapur District the Government of the United Provinces, India, is building a hydro-electric station on the Rihand River, near its confluence with the River Sohm. The cement necessary for constructing the dams, roads and bridges which form part of this scheme, is to be produced in a factory at Churk, the output of which is 700 tons per day. At present, the power for operating this factory, the main contractors for which were Vickers-Armstrongs Limited, Broadway, London, S.W., is being supplied from a steam station for which Brush Export, Limited, were sub-contractors.

The steam-raising plant consists of three stoker-fired water-tube boilers, which were manufactured by John Thompson Water Tube Boilers, Limited, Wolverhampton, and each of which has a maximum continuous rating of 30,000 lb. per hour at a pressure of 325 lb. per square inch and a temperature of 725 deg. F. when supplied with water at a temperature of 120 deg. F. at the economiser inlet. The fuel is low-grade Bengal coal with a gross calorific value of about 10,000 B.Th.U. per lb., an ash content of 18 per cent. and a volatile content of 23 per cent. In order to obtain the best results from this coal it is graded in crushers and screens before firing. Both forced and induced-draught fans are installed and the air to the fuel bed is controlled by dampers under the stoker.

ELECTRICAL EQUIPMENT

The three boilers supply steam to the same number of Brush-Ljungstrom turbo-alternators, each of which has an output of 2,400 kW at 3·3 kW, a frequency of 50 and a power factor of 0·9. This supply is given through a common steam range, although the pipework and valves are arranged so that each boiler can feed its own turbine independently. The alternators are connected to a 12-panel board equipped with Brush switchgear from which a supply is given at 3·3 kW to a switchboard in the mill house. This switchboard controls the whole of the power used in the factory and motor room, two 875-h.p. synchronous induction motors and two 775-h.p. synchronous induction motors being fed direct. In addition, the 3·3-kV sides of three 1,250-kVA 3,300/440-volt transformers and one 750-kVA 3·3/11-kV transformer and an overhead line to a pumping station are controlled from the same board. Power for the station auxiliaries is obtained from three 300-kVA 3,300/440-volt transformers. The turbine room is illustrated in Fig. 1 and the mill house in Fig. 2.

The secondaries of the three 1,250-kVA transformers are connected to a 14-panel switchboard from which feeders radiate to the various factory buildings. These buildings each contain a switchboard from which supplies are given direct to the large motors and to those of 30 h.p. or less through fuse distribution boards. The high tension side of the 750-kVA transformer is connected through an overhead line to a quarry some three miles from the factory where the voltage is stepped down to 440 volts and distributed to the plant through four feeders. All these transformers, with their associated switchgear and the motors they supply, were manufactured by the Brush Electrical Engineering Company, Limited, Loughborough, the total connected motor load being 8,934 h.p. The paper-insulated lead-covered power cables were manufactured by British Insulated Callender's Construction Company, Limited, 30 Leicester-square, London, W.C.2, and the aluminium-sheathed vulcanised-rubber cable used for the lighting circuits by Johnson and Phillips, Limited, Charlton, London, S.E.7.

One boiler, one turbine, high and low tension switchgear and a transformer for supplying the ancillary equipment form a unit which can be dismantled and installed in another power station when hydro-electric power is available.

DISTRIBUTION SYSTEM

The distribution system is designed so that in case of electrical breakdown one kiln and one half of the factory can be maintained in operation. The most vital sections of the plant are also connected so that a duplicate supply is always available. Electrical interlocks are installed on the conveyors, pumps and crushers so that all the plant can be stopped automatically and started up in the correct sequence. Each kiln is controlled from a panel on the firing floor to enable the operator to vary the speed of the conveyors and the rate of feed.

★ ★ ★

EXTENSION TUBES FOR SPRAY GUN

In order to paint inaccessible places, such as the interiors of pipes, a series of standard extension tubes for spray guns has been introduced by B.E.N. Patents, Limited, P.O. Box 10, High Wycombe, Buckinghamshire. These will take either circular, segment or angle-spraying nozzles and are made in lengths of 1 ft., 1 ft. 6 in., 3 ft., and 5 ft. The circular and segment sprays can be inserted in a ¾-in. diameter hole, but the 45-deg. angle spray requires a hole 1¾ in. in diameter.

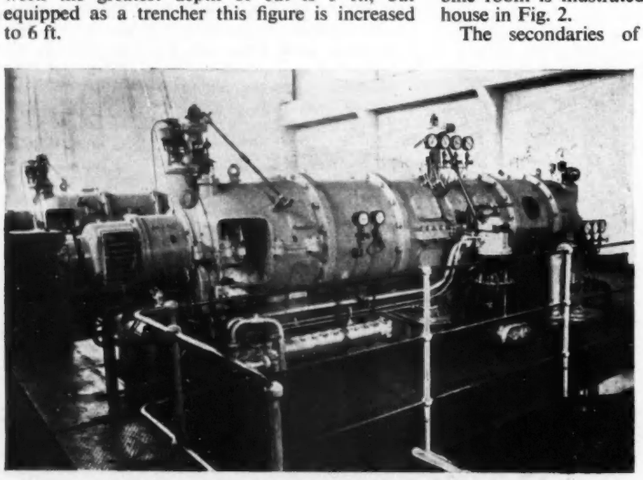


Fig. 1 One of the 2,400-kW Brush-Ljungstrom turbo-alternators.

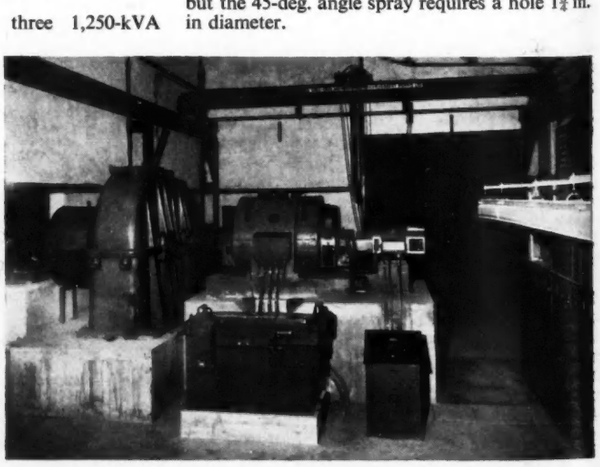
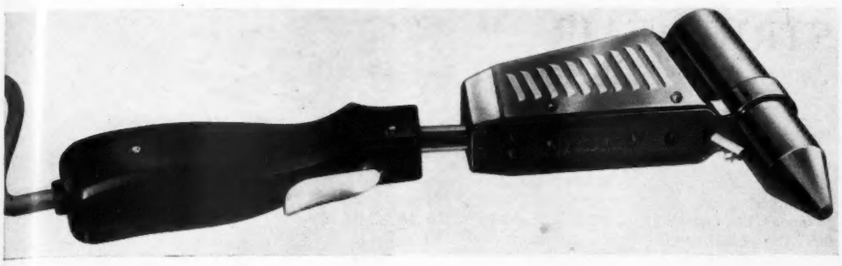


Fig. 2 View in the mill house showing 875-h.p. motor and control gear.



Aluminium soldering tool which both cleans and tins the metal surface at the same time and renders the use of flux unnecessary. It can also be used for joining other metals to aluminium.

SOLDERING ALUMINIUM

Difficulties of Oxide film Overcome without Flux

The successful soft soldering of aluminium and its alloys presents several problems, foremost among which is the difficulty of removing effectively the oxide film that is always present on the surface of the material and prevents the solder from "wetting" the metal. A soldering tool which is designed to clean and tin the metal at the same time is shown in the accompanying illustration; a small steel-wire brush arranged in the solder bit vibrates and cleans the surface by mechanical means. This action breaks up the oxide film and enables molten solder to tin the surface. No flux is employed. The joining operation can then be completed either with the tool or by any appropriate method.

The front of the Belark aluminium soldering tool, as it is called, consists of a copper rod with a copper-bit attached to one side and a heating element of 165 watts to the other. From the centre of the copper rod extends a steel bracket with carries the vibrator and junction box. The end of the bracket is fixed to a Bakelite handle. The steel-wire brush fits into the centre bore of the solder bit and is connected to the vibrator arm by a steel rod. The vibrator has a frequency of 100 cycles per second and is pivoted in one point with a spring support on one side and an adjustable screw on the other. The spring serves to compensate different heat expansions and the screw, working in conjunction with a locking device, brings the brush into the correct position.

To cope with the high heat conductivity of aluminium a highly-rated heating element, directly connected to the mains, brings the temperature of the tool up to 500 deg. C. The vibrator lies in a switch circuit controlled by the trigger in the handle. Both heating element and vibrator are covered by hoods, and all metal parts are chromium-plated to protect them from corrosion.

When the tool is switched on, it takes a few minutes to heat up. The bit is then placed in a vertical position on the aluminium surface and solder is applied until a pool of molten solder has formed round the bit; the vibrating brush is then brought into action by pressing the trigger and the tool moved over the surface, which becomes effectively tinned. Jointing is then carried out as in normal soldering. The solder recommended is 80 : 20 tin-zinc plumber's solder which has a melting point of 220 deg. C.

It is stated that exhaustive laboratory tests have been carried out with regard to tensile strength after the exposure of the soldered joints to various corroding atmospheres. With commercially-pure aluminium, however, the strength of the joints could not be established as the fracture occurred in the parent metal and not in the joint. Strength tests carried out on joints made of Dural showed failure at 2,460 lb. per inch run.

The tool is produced and marketed by the Belark Tool and Stamping Company, Limited, 33 Sussex-place, London, W.2.

SINGLE-TANK OUTDOOR CIRCUIT-BREAKER

A single-tank outdoor oil circuit-breaker has recently been introduced by the English Electric Company, Limited, Kingsway, London, W.C.2, which, it is claimed, provides the same electrical performance as the firm's three-tank breaker at a reduced price. It has a rupturing capacity up to 750 MVA at 33 kV and its weight, excluding oil, is 33¼ cwt. The air clearances are designed for 44 kV so that it can be employed at high altitudes and in polluted atmospheres. Its appearance is illustrated in Fig. 1, below.

The fixed contacts of this new breaker are of the self-aligning cluster pattern, there being no braids or riveted joints. The moving contacts, which give two breaks, are of the candle type and are made of light alloys so as to reduce the weight and give a faster speed of break. Both sets of contacts can easily be removed for maintenance without interfering with the setting or alignment.

ARC CONTROL DEVICE

The arc control device is of the natural flow type and has an outer cylindrical casing of synthetic resin, which is attached to the top contact block. This contains a number of labyrinths of arc-resistant material which are connected to vents and are shaped to form "passages" and "blind alleys." The passages control the flow of oil and gas which are created by the arc, and the blind alleys cause high-pressure pockets to be set up during the period of interruption.

When the contacts are closed all the vents are blocked, but are gradually exposed as the circuit is opened. The result is that some of the gas escapes and the arc is simultaneously subjected to a jet of cool oil which is forced into the labyrinth. As more oil is vaporised the internal pressure is maintained and the arc is further cooled by abstracting heat for vaporisation and by direct contact with the labyrinth. As current zeros are approached the arc diminishes and momentarily pauses with the result that the gas and oil become more effective and the dielectric strength of the contact gap increases. As the arc lengthens due to the parting of the contacts it is progressively exposed to an increasing number of oil jets until interruption occurs. A close-up view of the moving contacts, interrupters and current transformers round the bushings underneath the top plate is given in Fig. 2.

The cylindrical tank is fully phase-segregated with earthed metal barriers and is lined with insulating material. It is raised and lowered by self-contained winding gear, the framework being designed so that it can be withdrawn from either side. The bushings are of the oil-filled condenser type with spring-loaded porcelain weather shields and can be removed without disturbing the current transformers. As already mentioned, the current transformers are fitted round each bushing below the top plate which has been specially designed to receive them. They can be changed without disturbing the bushings. There is an oil seal on the secondary winding between the circuit-breaker tank and the control cabinet. The weatherproof control cabinet is, as will be seen from Fig. 1, attached to the breaker framework and contains the operating gear and auxiliary equipment. Operation can be by hand, motor-wound spring, solenoid or pneumatically.

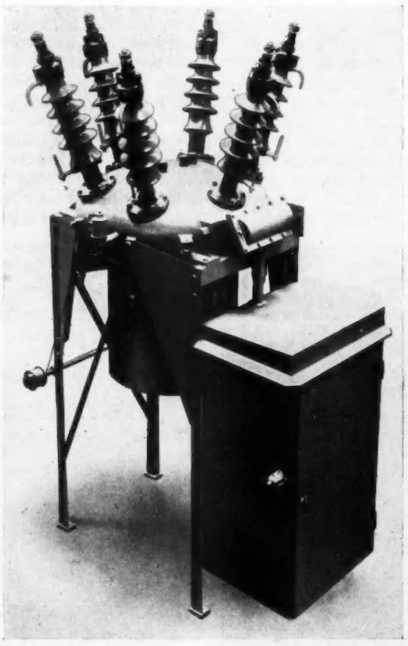


Fig. 1 33-kV three-phase single-tank outdoor circuit-breaker with natural-flow arc control.

★ ★ ★

HIGH-FREQUENCY TRANSISTOR

A point-contact transistor, type E.W. 51, has been developed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, for high-frequency work of the type met with in digital computors. As a pulse amplifier, the rise time of the output waveform is less than 0·15 microsecond when the input rise time is 0·05 microsecond. The rating for the collector dissipation is 100 milliwatts at 20 deg. C. Overall measurements of the metal container are ⅜ in. diameter by ⅜ in. in length.

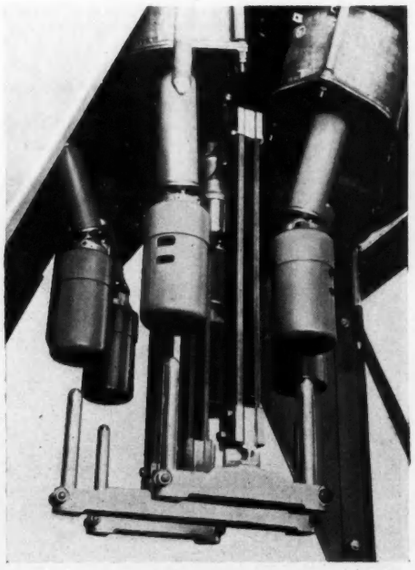


Fig. 2. Close-up of moving contacts, natural-flow interrupters and current transformers.

BRITISH INDUSTRIES FAIR

ENGINEERING EXHIBITS AT CASTLE BROMWICH

Concluded from page 606

The British Industries Fair, in London as at Castle Bromwich, closed last Friday, May 13. Some further engineering exhibits of particular interest are described below.

PORTABLE ELECTRIC GRINDERS

The stand of Wolf Electric Tools, Limited, Pioneer Works, Hangar-lane, London, W.5, showed a comprehensive display of their electric tools and equipment. These included a heavy-duty high-speed portable electric grinder. It carries either a 7-in. or 9-in. depressed centre reinforced wheel from $\frac{1}{16}$ in. to $\frac{3}{8}$ in. thick, which is driven by a single-phase or direct-current motor with an output of 1·5 h.p. The armature of this motor is dynamically balanced and the commutator and brushgear are completely sealed from the air ventilating the motor. The spiral bevel gearing and spindles are of nickel-chrome alloy steel and are high-frequency hardened. They are mounted on ball and needle roller bearings and the driving flange for the grinding discs is of moulded rubber.

BAILEY BRIDGE DEVELOPMENTS

A composite Bailey bridge structure, embodying the latest developments, dominated the stand of Thos. Storey (Engineers) Limited, Stockport, Cheshire, at the outdoor section of the Fair. The bridge, over 200 ft. long, was an example of the type of equipment which could be used for road and bridge expansion programmes, and is available under the company's Bailey bridge hire service. Inaugurated last year, the hire service is operated in conjunction with the normal sales programme, and provides equipment for either temporary or permanent bridging. The equipment is suitable for many purposes, such as form cages and falsework, apart from the more conventional bridging, and a full description of the applications of this equipment to peace-time operations was given in ENGINEERING last year (vol. 178, page 218, August 13, 1954).

In addition, the firm were showing, in public for the first time, two recent developments: an expanding panel pin and prefabricated steel decking. The expanding panel pin has been designed to take the place of the normal panel pin when the elimination of sag is desirable. The pin is in two parts, a taper pin and a sleeve. The sleeve is split along the full length and has a taper in the bore corresponding to that on the pin, so that driving the taper pin into its sleeve forces the latter to expand, thereby more completely filling the hole in the panel.

The prefabricated unit-construction steel decking which is the most recent development is shown in Fig. 28, and is supplied in readily assembled units. It can, in the case of temporary bridges, be used either with or without the addition of normal road surfacing and, in permanent bridges, it forms the base for a tarmacadam or similar road surface blending the roadway of the bridge with the approaches.

The prefabricated steel decking units take the place of both stringers and timber chesses as used in the original Bailey bridge, and are designed to enable them to be utilised on the standard, standard widened or extra wide bridges of the flush-deck and pontoon types.

Also on display was trestle equipment which consists of built-up box sections, in four standard lengths, for supporting various types of bridging equipment, derricks or other load-bearing structures. It is braced in the vertical and horizontal planes by angle sections, and may be provided with decking if required. R.S.J.'s form the top and bottom bearers, and the whole is fixed together by bolts and nuts.

PROCESS TIMERS

Electrical Remote Control Company, Limited, Harlow New Town, Essex, were showing a number of patterns of their multiple-contact relays and process timers, as well as of their low-voltage soldering irons and control panels.

Among the process timers, mention may be made of the automatic self-resetting synchronous pattern, which is illustrated in Fig. 29. This consists essentially of a miniature synchronous motor, an electromagnetic clutch with a timing disc and setting and re-setting mechanisms. Operation is initiated by closing the control circuit either by an external on-off switch or by a push button, limit switch or relay. The timer is then energised within a period of 0·1 sec., when the pointer moves from zero towards the time marking that has been set. The unexpired time is indicated by the moving pointer, while the original setting is shown on the time dial. At the end of the timing period, or when the supply is disconnected, the timer is re-set automatically within 0·5 sec. for the next operation.

The current carrying capacity of this apparatus is either 2 amperes or 5 amperes at 230 volts alternating current, but can be increased by the use of external relays or contactors. It can be supplied with a number of time ranges varying from 0 to 12 sec. up to as much as 0 to 7 days. It can also be supplied with internal contact arrangements which enable over 85 standard duties to be performed. Typical of these is "make" during the timing period where an impulse is given to the timer by an external push button or limit switch. A pair of internal contacts is then closed and remains closed during the timing period. At the end of this period the contacts open and the timer is re-set automatically.

Fig. 28 Prefabricated steel decking for Bailey bridges giving a closer joint than earlier types. Thos. Storey (Engineers) Ltd.

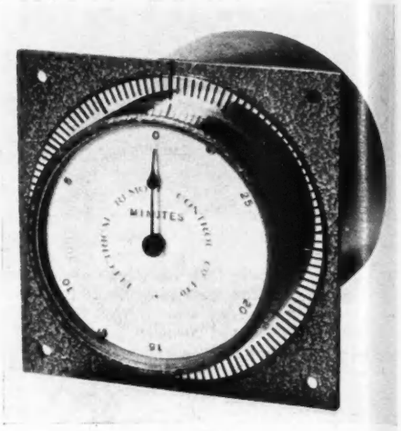


Fig. 29 Automatic process timer, available with ranges from 12 seconds to 7 days. Electrical Remote Control Co. Ltd.

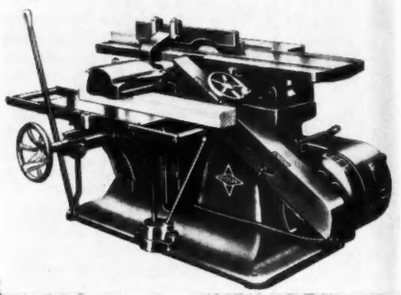


Fig. 30 Universal woodworking machine for sawing, planing, moulding, tenoning, etc. Midland Saw & Tool Co. Ltd.

WOODWORKING MACHINERY

Several examples of their "Midsaw" range of machinery were shown by the Midland Saw and Tool Company, Limited, Pope-street, Birmingham, 1. They included a 26-in. motorised saw-bench, motorised bandsaws for wood, and a crosscutting and grooving machine. The latter has a fabricated steel box-type base, with a vertical post carrying a horizontal arm on which the saw and motor are mounted. The vertical post can be rotated and locked in any position, and the motor and saw can be adjusted for bevel work up to 90 deg. The table is of hardwood, adjustable backwards and forwards. The machine carries a 14-in. diameter saw, which moves over a distance of 20 in., and with the saw set at right-angles to the table can be used for simple crosscutting. Bevel crosscutting, mitreing and compound mitreing can be carried out with the saw and horizontal arm set at the appropriate angles. A grooving head can be fitted in place of the saw, and the machine can then be used for grooving as required.

UNIVERSAL WOODWORKER

The "Midsaw" universal woodworker (Fig. 30) is a combination machine designed for use in smaller establishments and maintenance workshops. It has a ball-bearing spindle mounted horizontally and is available in two sizes. The 6-in. machine is capable of planing up to 6 in. wide, and carries a 14-in. diameter circular saw, while the 9-in. machine will plane up to 9 in. and has an 18-in. diameter saw. Both sizes of machine are adapted to carry out a

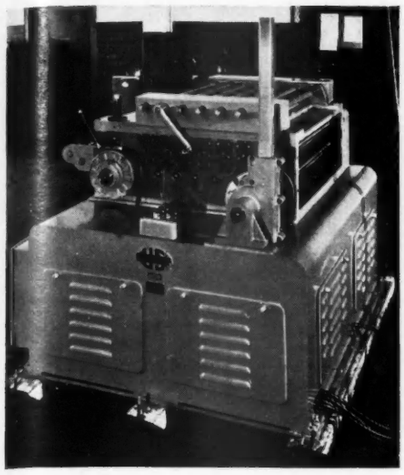


Fig. 31 Straightener for press feed taking material 0·062 in. thick by 48 in. wide. Rockwell Machine Tool Co. Ltd.

variety of operations including sawing, planing, surfacing and thicknessing, moulding, rebating, boring, tenoning, grooving, half-lapping, and mortising. The machine has two tables, the main or front table being above the spindle and the thicknessing or rear table below. The main table is arranged to rise and fall by means of enclosed gears and a handwheel. To change tools the table is lifted to give access to the spindle, the lifting being done by the raising gear on the 9-in. machine. On the 6-in. machine the table is light enough to be lifted by hand, and a hinged prop is provided to hold it up while the tools are changed. The rear table traverses in three directions when required for mortising. On the 9-in. machine the driving motor, which is of 8 h.p., is of two-speed design, giving speeds of 2,000 and 4,000 r.p.m. at the spindle. A single-speed motor of 4 h.p. gives a spindle speed of 3,000 r.p.m. on the 6-in. machine.

FEED STRAIGHTENER

Among the machines being shown by the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, were: a 12½-ton press fitted with slide feed, straightener, uncoiler, stock-oiler and scrap-cutter to render it entirely automatic; cycling feed equipment; and various models of stock straighteners. One of the latter, illustrated in Fig. 31, was shown for the first time at the B.I.F. Known as the model PDFS48, it is a power-driven machine for handling stock up to 48 in. wide and 0·062 in. thick. There are a set of driven take-in and take-out rollers and twelve straightening rolls, of which the lower six are driven. The maximum feeding speed is 60 ft. per minute, and the stock passes directly to the press without any intermediate loop. Power is supplied by a 5-h.p. variable-speed motor. To stop the feed, an air clutch disconnects the motor and at the same time two electric brakes are applied to the lower take-in and take-out rolls. This is arranged to occur at each revolution of the driving eccentric. The feed per turn of the take-out rolls is approximately 15½ in., and the eccentric can be set to feed less if desired. To feed more, an electric counter comes into operation which stops the feed when the required amount of stock has been fed through. At the same time, the press mechanism is tripped. On the return stroke of the press ram, a limit switch is operated which restarts the whole cycle. An inching control is provided for initial setting up.

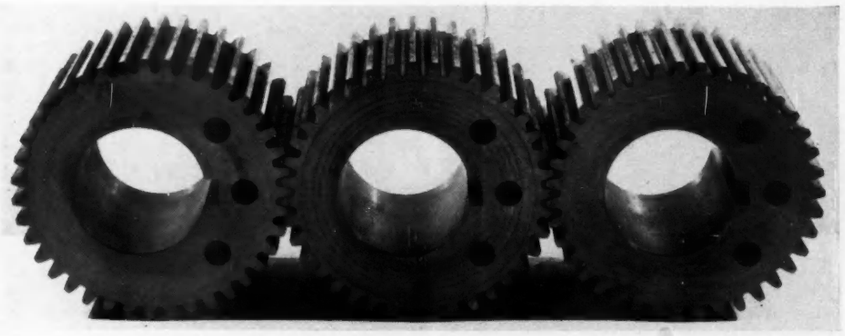


Fig. 32 Special-purpose eccentric elliptical spur gears for use in tinplate shearing machine. George Angus & Co. Ltd.

COIL CRADLE

Ancillary to the straightener is a coil cradle also handling material up to 48 in. wide and coils up to 54 in. in diameter. The coil rests on four power-driven rollers which assist in threading the material into the pinch rollers, and also ease the draw-off mechanism when the material is being fed out. The rotation of these rollers can be reversed. A 3-h.p. geared motor supplies the power and a mercury-switch loop-control mechanism is incorporated.

ECCENTRIC ELLIPTICAL GEARS

George Angus and Company, Limited, 152-158 Westgate-road, Newcastle-upon-Tyne 1, were showing on their stand a variety of products ranging from fire hose to special gears. Among the latter was a pair of eccentric elliptical gears mounted on a roll testing machine for demonstration purposes. Trains of three of these gears, as shown in Fig. 32, are being used in one type of high-speed rotary tinplate shears. The use of such gears gives a variation in speed of the driven shaft during each revolution, which is a useful feature for some special applications.

These particular gears have a centre distance of 10 in.; the face width is 6½ in. and there are 39 teeth. The bores are drilled 0·8645 in. out of centre and the difference between major and minor axes is 0·140 in. The maximum allowable backlash in any position of mesh is 0·005 in. As the running speed is comparatively high, even for normal spur gears (1,000 ft. per minute at the periphery), the manufacture demanded extreme care and accuracy.

LIGHTWEIGHT TRAILER

In Fig. 33 below, a small tandem roller is shown being run on to the deck of the "Easiload" trailer made by, and exhibited on the stand of, Stothert and Pitt, Limited, Bath. This trailer has been designed as sturdy general-purpose equipment specially adapted to operate on contractors' sites, enabling one man, on his own if necessary, to load small rollers and mixers weighing up to 1 ton, of which the company's 3½T and 5T hand-fed mixers are examples.

The trailer frame is constructed of steel channel and angle sections; the decking is made of 1¼-in. timber and has a length and a width of 8 ft. 2 in. and 4 ft. 2 in. respectively. From the deck, the side joists have a height of 5¾ in. and are fitted with six eye bolts for lashing down loads when required. The general features of the trailer can be assessed from the illustration, though it is to be noted that the springs are of the independent rubber torsion type fitted to crank arms. The brakes are of the 10-in. internal expanding type worked on the over-run principle by steel cables, with the additional provision of a hand parking brake. Either a ball or an eye coupling is fitted on the towing coupling which allows a towing height of between 2 ft. 3 in. and 2 ft. 9 in. above ground level.

Standard accessories are twin tail lamps and reflectors, number plate, trailer plate and

Fig. 33 Lightweight trailer for contractors' plant. Designed for loading by one man. Stothert & Pitt Ltd.

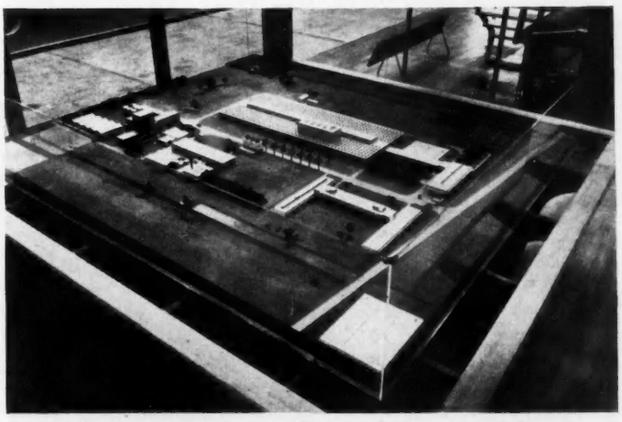


Fig. 34 Model of Burmese pharmaceutical plant with window frames and cladding of pressed metal. Henry Hope & Sons Ltd.

Fig. 35 Machine for rapid production of building blocks up to about 1,380 per hour. Alan R. Davies.

Fig. 36 Machine for moving building blocks (see Fig. 35). Alan R. Davies.

electrical coupling to the towing vehicle. The combined tailboard and ramp is a reinforced steel plate that is held in the closed position by chain and cotter fastenings; it has the secondary function of providing support at the rear which, in conjunction with an elevating screw at the front, enables the trailer to be lifted clear of the ground to permit wheel changes. For mechanical loading a ¾-ton " Pul-Lift " can be supplied if required; this has a chain 10 ft. long with a hook at each end, and can be easily removed for general use about a site.

WINDOWS AND WALL CLADDING

The principal exhibit on the stand of Henry Hope and Sons, Limited, Smethwick, Birmingham, was the model, shown in Fig. 34, of the buildings comprising a development project for the pharmaceutical industry of Burma, located at Rangoon. Hopes are the main sub-contractors, supplying the metal window frames and window gearing, the patent glazing, pressed-metal louvres and the wall cladding.

The buildings and engineering services (excluding the manufacturing plant) are expected to cost £2,500,000, and to be completed by the autumn of 1956. There are to be three main sections: the alcohol and yeast vitamin plant, which will together have an annual output of 2,400 gallons of alcohol and a quarter of a ton of yeast per day; the biological institute, comprising laboratories, animal farm and operating unit, designed to produce vaccines and sera required by Burma; and the main production building for the manufacture, storage and packing of pharmaceuticals.

Much of the building is to be constructed from factory-made units; this has the double advantage of overcoming the difficulty of the scarcity of skilled labour and of permitting very rapid erection above slab level—important where building operations are seriously affected by monsoons for nearly half the year. Half the main building is required to be air conditioned, and adequate cross-ventilation to the other half is to be achieved by installing banks of power-operated louvres along a raised centre portion of the roof above the mezzanine gallery. The roof construction has been designed to have a double-skin roof which will not only conceal most of the service pipes but which will also give the high degree of thermal insulation that is required. The architects are James Cubitt and Partners, and the principal contractors Holland and Hannen and Cubitts, Limited, 1/3 Queen Anne's Gate, London, S.W.1. Last month the model was presented to H.E. the Chargé d'Affaires of the embassy of the Union of Burma, by whose permission the model was displayed.

MAKING AND HANDLING BUILDING BLOCKS

Modern methods of making and handling green building blocks, including the handling of the aggregates, the actual making of the blocks, and the movement of the finished block after curing, were demonstrated on the outdoor stand of Alan R. Davies, 47A Zetland-road, Bristol, 6. This company is the sole concessionaire in the British Isles for the " Multibloc " range of equipment which is designed for the efficient production of a building block, the standard size of which is 17⅝ in. long by 8⅝ in. high; the thickness can be varied from 2 in. to 6 in. if the block is solid or up to 8¼ in. if the block is hollow.

The equipment, all the machines of which have been designed to work in conjunction with each other for the economic production of the blocks, includes: the feed truck for handling and tipping the aggregate; the blockmaking machine itself; a lift truck used for moving the green blocks as soon as they can possibly be moved; a carrier truck for transporting the blocks to stacking and curing areas; and, finally, a grab for slinging numbers of the blocks without damage on to stockpiles or lorries. The first two pieces of equipment—the feed truck and the blockmaker—are shown in Fig. 35, above, and the lift truck, used for moving the newly-made blocks, in Fig. 36.

As will be realised by inspection of Fig. 35, the " Multibloc " machine is designed for receiving and consolidating the pre-mixed aggregates; each batch of blocks—or " drop "—is compacted on the ground, the blocks released from the expanding moulds which are lifted clear, and the machine is wheeled to the next position, where the manufacturing process is repeated. For a fair day's work—500 drops—a firm level site of 6,000 sq. ft. is required, if adequate passage-way is to be left between lines of newly-laid blocks. Power for the agitators, vibrator and hoisting gear is obtained from electric motors supplied from the mains through a trailing cable.

The lift truck is designed to pick up a " drop " of the bricks while they are still green and inclined to crumble. Mounted on pneumatic-tyred wheels, the truck is manoeuvred over the blocks which are gripped back and front by rubber-faced boards. As the handle of the truck is pulled down into the normal pushing position the blocks are lifted clear of the ground for wheeling elsewhere, so clearing the site for more block making. The machine lifts one edge of the drop of blocks slightly before the other, so that they are not damaged by adhesion to the ground. The clamping faces are 54 in. long, enabling nine 6-in. blocks to be moved at once. The carrier is arranged to take three drops at each load and this is also the capacity of the hoist grab. At the exhibition, the hoist was shown running on a gantry supported by A-frames and with an overhang one end. By its use, lorries can be loaded in a very short time. The whole equipment is designed to work together and is adequate to handle the high output from the block maker, which can easily produce 1,380 blocks, 2 in. thick, per hour.

Fig. 37 Electrically-operated actuator for adjusting boiler dampers. English Electric Co. Ltd.

ELECTRICALLY-OPERATED ACTUATOR FOR BOILER DAMPERS

The exhibits on the stand of the English Electric Company, Limited, Kingsway, London, W.C.2, comprised examples of their " Superform " fuse switchboards and ancillary equipment; high rupturing-capacity fuse links; meters, instruments and relays; and a selection of motors. The latter included designs conforming to British Standard dimensions and to American standards.

The principal exhibit, however, was an electrically-operated actuator for the remote control of boiler dampers. This equipment, which is illustrated in Fig. 37, consists essentially of a 415-volt, two-pole induction motor, a gearbox and a screw jack which converts the rotary motion of the motor into a linear stroke. It is mounted between the damper operating arm and a bracket attached to the flue, a coil-spring buffer being incorporated to enable a pre-determined pressure to be applied to the damper in the closed position. The coupling between the actuator and damper arms includes

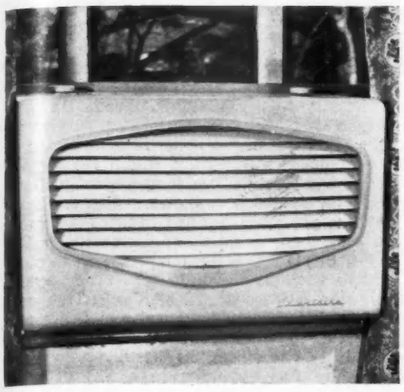


Fig. 38 Air-conditioning plant to fit in or below a window. Scientaire Ltd.

a shear pin so that the mechanical load is limited to 3,200 lb. Operation is controlled by a three-position toggle switch, which is returned to its central " off " position by a spring.

The positions of the dampers are indicated on instruments which are normally installed above the control switches, the termination of the stroke of the actuator being indicated by coloured lamps. These instruments are connected to a transmitter which consists of a rotary potentiometer and is coupled to the arm operating the damper by a link.

Arrangements can be made for the damper to be closed automatically by including interlocks in the actuator control circuit on the fan starter. These interlocks open in event of a fan failure. The indicating instruments are supplied at 48 volts from an auxiliary transformer.

ROOM-AIR CONDITIONER

A complete air conditioning unit that will fit in or under the window of a room, was being shown by Scientaire Limited, 2 Blenheim-terrace, Leeds, 2. It is illustrated in Fig. 38. The unit consists of a laminated glass-fibre moulding which projects 10¾ in. into the room as shown and 22½ in. outside the wall. Within this cabinet, and mounted on a tray for easy removal, are the refrigerating, drying and filtering units. A heating unit can be included if desired.

Room air is drawn in through an opening at the lower edge of the cabinet and is mixed with outside air in any desired proportion, the mixing being controlled by a damper operated by a knob on top of the cabinet. The mixed air is passed over the cooler of the refrigerating unit by a centrifugal multivane fan. The refrigerating unit is hermetically sealed and consists of a single-cylinder compressor driven by a capacitor-type motor, a cooler and a condenser. After cooling and drying, the air is passed through a replaceable filter before being guided into the room by the adjustable louvres.

Two models are made, one with a ¾-h.p. motor and the other with a 1-h.p. motor. These have deliveries of 350 and 500 cub. ft. of air per minute and heat capacities up to 11,400 B.Th.U. per hour. Both models measure 28¼ in. wide and 16½ in. high, and can be fitted to any window up to 48 in. wide, using the standard fittings available. Standard power supplies are 200/250 volts, 50 cycles, or 110 volts, 60 cycles.

RUST REMOVAL AND PREVENTION

The Plus Gas Company, Limited, 1-11 Hay-hill, London, W.1, were showing two cleaning fluids, Formula "A" for rust and corrosion removal, and Formula " B " for the protection of surfaces against rust. Formula "A" has a very low surface tension, which enables it to penetrate between corroded surfaces at high speed and so to break the corrosion lock. It can be used on all ferrous metals and on aluminium, and for the removal of carbon deposits from engine components. Formula " B " is resin-based, dries quickly, and forms an extremely thin coating which in many cases need not be removed before using the treated components. The fluid is normally transparent, but it can also be supplied in colours for component identification.

* * *

PRESTRESSED PRE-CAST MANHOLES

A section of the Crawley Development Corporation's northern trunk foul sewer had several deep manholes varying from 25 ft. to 40 ft. deep designed in engineering brickwork. Owing to the difficulty of obtaining the bricks in time the contractors, Mears Bros. (Contractors), Limited, submitted a proposal for prestressed, pre-cast manholes which had the following advantages over brick manholes: (*a*) a reduction in cost; (*b*) a saving in time of construction; (*c*) a much stronger construction with good concrete and a smooth finish; and (*d*) a guarantee that the manholes would be waterproof. This latter point was of the utmost importance as infiltration of ground water into foul sewers, in any substantial amount, would cause a heavy overloading of the sewers and treatment works.

The concrete manholes consisted of six chamber sections, a roof unit and a varying number of shaft units. The chamber sections, each 18 in. deep, were egg-shaped in plan to give the desired minimum width of 4 ft. 3 in. and reducing to the shaft size of 2 ft. 9 in. at one end. The first two sections were made in two pieces to leave access for the 30-in. diameter sewer. The spaces between these sections and the sewer were cast *in situ* together with the pipe surround and concrete benching. The form of the chamber and shaft members are to be seen in two of the accompanying illustrations.

The chamber was covered with the roof unit and the shaft units, each 4 ft. deep, rested on this. The whole sections were tied in with three prestressing cables, one being anchored on top of the chamber roof, and the other two cables continuing right up through the shaft units and anchored in the recesses left in the cover slab. A tongued-and-grooved joint was formed between sections and a strip of rubberised bitumen inserted in this. On stressing the cables, the joints closed up and made the manholes quite waterproof. Moreover, the stressing gave them considerable shear strength to resist possible ground movements.

The pre-cast sections were reinforced with inside and outside mild-steel reinforcing bars and were of vibrated concrete with a 28-day strength of 7,500 to 8,000 lb. per square inch made under factory conditions at the contractor's works. The cables consisted of six 0·2-in. diameter high-tensile steel wires and were stressed to 70 tons per square inch. The anchorage and jack were also developed by the contractors. The anchorage consisted of a split tapered cone of mild steel (with a case-hardened thread inside) which fitted into a mild-steel anchor plate through which a grouting hole was left. An example of the Mears anchorage is shown in the third illustration. The prestressing jack consisted of two hollow jacks, one of 40 tons and the other of 15 tons capacity. The main jack was operated first to stress the wires, the secondary jack being used to force home the tapered cone. The wires were anchored at the bottom of the manholes by being turned up and concreted in with the *in situ* benching, etc. It was found very convenient to grout up the cables immediately before stressing by simply pouring a 1 : 1 sand-cement grout down from the top until the holes were full.

All the pre-cast sections were less than 30 cwt. in weight and were lowered into position by a 10 R.B. Excavator. Just under an average of two days per manhole were required to complete each manhole, with an additional three days for the *in situ* benching, etc.

The manholes have been found to be very successful and this form of construction seems to offer an economical solution to the construction of deep manholes.

The chamber sections of a 40-ft. deep manhole in position, showing the cable holes and the joint.

Access shaft to a complete manhole approximately 20 ft. deep. The left-hand cable has been stressed but the wires have not been cut.

The " Mears " anchorage for cables of six or seven wires using a split tapered cone. Where six wires are used—as here—a threaded bar is used in the centre to complete the anchorage.

MODIFICATIONS TO A STEAM-DRIVEN PUMPING PLANT

RAISING THE EFFICIENCY OF 40-YEAR OLD PLANT

In a paper presented at a meeting of the South-Eastern Section of the Institution of Civil Engineers, on March 23, 1955, and reprinted in the March issue of the Journal of the Institution of Water Engineers, Mr. W. Grant Gibson, A.M.I.C.E., gave a detailed account of modifications made to the steam-driven plant at the Fleam Dyke pumping station of the Cambridge University and Town Waterworks Company. The matter is of much interest as showing the improvement in overall performance that can be achieved by detail modifications of plant which would now generally be considered to be of somewhat outmoded type. The construction of the station was commenced in 1912, but, owing to delays imposed by the First World War, was not completed until 1921; the design of the plant may be taken as *circa* 1912. The detail modifications and improvements which have been carried out, have resulted in a reduction of 570 tons in coal consumption a year, and a net annual saving of £2,390.

The plant consists of two Hathorn Davy horizontal tandem compound steam engines, one right-handed and one left-handed, driving double-acting piston force pumps and single-acting well pumps from backward extensions of the piston rods by opposed quadrants. Steam is supplied at 120 lb. per square inch by one of three Lancashire boilers, made by Messrs. John Thompson and Company, fitted with Sugden superheaters in the downtake. There is also a Green's vertical-tube economiser common to all three boilers and installed in 1948. Prior to the modifications with which the paper is concerned, the boilers were hand-fired. The plant performed satisfactorily in terms of the standards ruling when it was designed and built, but rising charges, and particularly the increase in the cost of coal, made it desirable to attempt to improve the overall efficiency. The first steps taken consisted in a thorough overhaul and the introduction of systematic records of performance, and thermal-efficiency trials.

PROPOSED ALTERATIONS

The measures taken resulted in an improvement, but it was considered that more could be done. Mr. H. R. Lupton was consulted and asked to recommend the best way to deal with the installation with a view to improving its performance. On economic grounds, and in view of the capital costs which would be involved, he advised against the replacement of the plant by either electrically- or Diesel-driven centrifugal pumps, and proposed a number of modifications which would considerably improve the efficiency of the steam plant. These were raising the initial superheat; jacketing the engine cylinders, reheating the l.p. steam; provision of mechanical stokers; enlargement of economiser; removal of induced-draught fan; boiler feed pumps to be driven by main engines; displacement of force pumps to be made equal to that of the well pumps; holding-down bolts to the main diagonal pedestal bearings at the cranks to be renewed; and provision of a steam-driven alternator.

The modifications were estimated to result in a net saving of £1,785 against a capital outlay of £8,150. The saving of fuel was estimated at 27 per cent., due in the main to the higher superheating, the cylinder jacketing and the reheat. All the main recommendations were adopted. At the time of writing the paper, the induced-draught fan had not been removed; the purpose of the proposal was to save the cost of the current consumed by its driving motor. The steam-driven alternator has also not been installed. The purpose of this item in the proposals was not to reduce expenses, but to provide power for the auxiliaries in the event of failure of the public supply. As, however, experience showed that in the event of such failure, resulting in the closing down of the induced-draught fan, the economiser scraper gear and the stoker drive, the economiser could be by-passed and the fan dispensed with, since the chimney created sufficient natural draught for the plant to continue in operation, and the boilers were hand-fired.

SUPERHEATERS INSTALLED

The higher initial superheat, the steam-jacketing of the cylinders and the reheat, aimed at effecting an improvement in the dryness of the steam in its passage through the engine. Earlier trials had revealed excessive wetness. The initial steam temperature, after the alterations, was limited to 750 deg. F. because with the low load on the boiler the temperature of the gases in the downtake was not expected to be much above 1,000 deg. F., leaving only a small temperature-difference for heat transfer. The adoption of a moderate superheat also obviated the need for expensive heat-resisting steels. The steam-jacket pressures were taken as boiler pressure for the high-pressure cylinder and 60 lb. per square inch for the low-pressure cylinder. The reheater was designed for a steam-inlet temperature of 750 deg. F. and an outlet temperature of 600 deg. F.

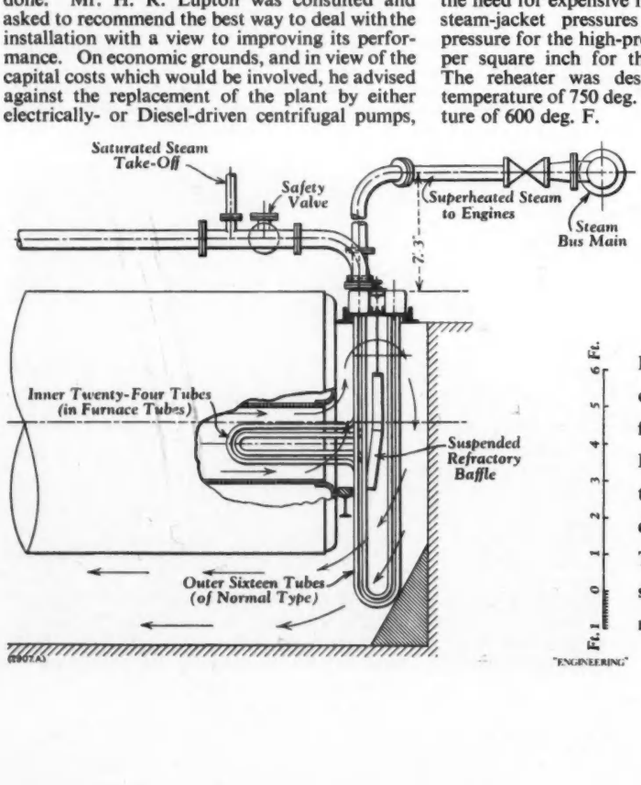

Saturated Steam Take-Off
Safety Valve
Superheated Steam to Engines
Steam Bus Main
7' 3"
Inner Twenty-Four Tubes (in Furnace Tubes)
Suspended Refractory Baffle
Outer Sixteen Tubes (of Normal Type)
Ft. 1 0 1 2 3 4 5 6 Ft.
"ENGINEERING"

Fig. 1 By the installation of new auxiliary plant the fuel consumption of the Fleam Dyke pumping station, Cambridge, was reduced by 34·2 per cent. The illustration shows in side elevation the arrangement of the new superheaters.

The new superheaters were made by Sugdens, Limited. Because steam could be raised easily by one boiler, only two of the three boilers were modified, the third being reserved for emergency use only. The heating surface of the original superheaters was 135 sq. ft.; with the new arrangement it was raised to 328 sq. ft. Owing to the low load on the boiler it was decided to provide superheater surface within the furnace tubes so as to give a large temperature gradient. The new arrangement is shown in Fig. 1. Steam flow takes place first through 16 tubes of normal type and then, because of increased specific volume due to rise of temperature, through 24 tubes each having a hairpin bend located within the furnace tubes. Although the new superheaters are designed to give a final steam temperature of 700 deg. F., this is rarely attained because the modifications as a whole have resulted in fuel economy in excess of what was expected, with a corresponding reduction in the total heat input. Tests before and after the modifications showed final steam temperatures of 524 deg. F. and 627 deg. F.

The engine cylinders have barrels cast integral with jackets, the jacket spaces being 3 in. wide. The covers are also hollow. The original intention was that the jacket spaces should be held under condenser vacuum, with a view to reducing heat loss. It was the practice, however, to run them filled with air. The jacket spaces were subjected to hydraulic tests and proved sound and reliable. The h.p. spaces were tested at 200 lb. per square inch, the working pressure being 120 lb., and the low-pressure spaces at 120 lb. for a working pressure of 60 lb. Two methods of supplying steam to the jackets were considered, the first being the provision of a de-superheater section in the reheater, steam being taken from it; the second was the provision of an independent saturated steam main. The latter method was adopted, partly because a saturated-steam main had, in any case, to be provided for the barring engine and a steam winch, and also because it was feared that when warming a standing engine, highly superheated steam might be admitted to the jackets because, with the engine stopped, the de-superheater in the reheater would be ineffective. The high-pressure jackets are fed directly from the boiler with saturated steam and the low-pressure jackets through a Hopkinson reducing valve.

The original plant included a large steam separator in the main steam pipe, located over each low-pressure cylinder. The use of superheated steam made the separator redundant and it was decided to remove it and fix the reheater in its place. The reheater, shown in Fig. 2, was made by the Bristol Piping Company. It is of all-welded steel construction. High-temperature steam, at 120 lb. per square inch gauge, enters the upper header which has a mild-steel dividing wall. The steam flows down one half of the vertical tubes and up the other half via a floating bottom header, which is drained by a ¾-in. diameter mild-steel tube curled into a flat spiral. It is led through the bottom of the low pressure section to the hot well. The upper header is provided with a 2½-in. diameter by-pass valve for temperature control of the steam passing to the high-pressure cylinder.

STOKING

As in the case of the extended superheaters, only two of the boilers were equipped with mechanical stokers, the third, used only in emergency, remaining hand fired. The employment of pulverised coal was considered, but the capital cost of the pulverising plant, the question of maintenance and the fact that the boiler attendants had no special or technical knowledge ruled it out. A Hodgkinson low-ram coking stoker was finally decided on. The choice was determined by the robust simplicity, the low driving power required and the suitability of a coking-stoker for the bituminous coal with over 30 per cent. of volatiles which was in use. The stoker is driven by electricity from the public supply and in emergency, the boilers can be satisfactorily hand-fired. The suggested enlarge-

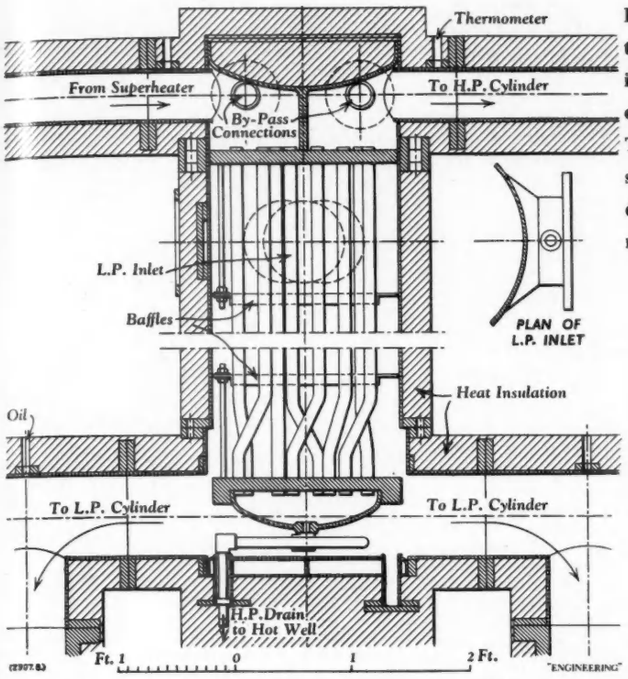


Fig. 2 In the original plant there were large separators in the main steam pipe over each low-pressure cylinder. The use of superheated steam made them redundant so they have been replaced by reheaters of the type shown here.

ment of the economiser was not carried out, because the progressive reduction of the heat input showed signs of lowering the temperature of the gases below that which was deemed safe.

The boiler-feed pump arranged to be driven by the main engine is a standard Clarke Chapman double-acting pump with a 4-in. in diameter piston and a maximum stroke of 10 in. A similar steam-driven pump is retained in the boiler house for emergency use. The pump is driven from the back well-pump quadrant shaft through a variable-stroke mechanism. A slotted block is secured to the end of the quadrant shaft. The stroke is varied by traversing a dovetailed rocking arm across the block by means of a worm reduction gear. The stroke of the pump may be varied from zero to 9·5 in. The arrangement has proved very successful; the pump stroke may remain unaltered for hours of running because, being geared to the main engine, the pump discharge is self-regulating in accordance with the demand for steam.

The purpose of the recommendation that the displacement of the force pumps should be made equal to that of the well pumps was to save power. A test had shown that the well-pump discharge was 159,690 gals. per hour and the force-pump discharge 148,212 gals.; the difference, 11,478 gals. per hour was returned to the well. It was calculated that this represented a waste of 3·85 per cent. of the power used. The fitting of new working barrels to the pumps presented no mechanical difficulty. The renewal of the main pedestal bearing bolts which was suggested, and which was carried out, was intended to improve availability and was not among the measures taken to effect savings.

SAVINGS OBTAINED

As mentioned above, these modifications to the plant were estimated to result in a net saving of £1,785 per annum, actually they were so successful that the saving was £2,390. The capital expenditure, somewhat higher than estimated, was £9,697. Interest and sinking fund on this imposed an annual charge of £661. There were two other increased charges, the power to drive the stokers amounting to £24 a year, and £200 representing the increased cost of lubricating oil. On the credit side, 570 tons of coal at £5 gave an annual saving of £2,850 and there was a saving of £425 per year for labour. The overall result gave the satisfactory figure of £2,390 quoted above.

The result is analysed in detail in the paper. Thermal-efficiency trials in 1950 and 1954 showed the B.Th.U. per w.h.p.-hour at 35,095 in the former year and 23,104 in the latter. This represented a fuel saving of 34·2 per cent. Of the various items which contributed to this result, the heat input to the engine showed a fuel saving of 20·6 per cent. and the heat output from the steam-raising plant one of 19 per cent. A fuel saving of 8 per cent. was due to the mechanical stokers alone, and 10 per cent. to the stokers in conjunction with the larger superheaters and improved heat insulation. There was no way of calculating the fuel saving due to the direct drive of the boiler-feed pump; it was estimated at 4·5 per cent. A saving of 2·73 per cent. of w.h.p. was achieved by the force-pump modification.

* * *

TWO NEW ROCKET MOTORS

The existence of two new liquid-propelled rocket motors has been announced recently—the Armstrong Siddeley Screamer and the de Havilland Spectre. Both of these motors have been running for some time and are expected to commence flight trials this summer.

The Screamer, constructed by Armstrong Siddeley Motors, Limited, Coventry, is described by the manufacturers as being "the next generation along from the Snarler." The latter engine was described in ENGINEERING in our March 11 issue this year, and the September 17 issue, 1954.

It can be used either as an independent power unit or in conjunction with a jet engine to give enhanced rate of climb and performance at high altitude, and is intended for use in supersonic interceptor fighter aircraft, as is also the Spectre designed by the de Havilland Engine Company, Limited, Edgware, Middlesex.

Experience gained with the Super Sprite assisted-take-off rocket, the first British liquid-propellant rocket engine to pass a Ministry of Supply type-approval test, has been applied to the de Havilland Spectre. The combination of the Spectre and the Gyron type of high-powered jet engine will provide a mixed-power-plant formula which, in addition to the more obvious advantages of speed, acceleration, and manoeuvrability in the stratosphere, makes possible an ability to take-off rapidly and to maintain an outstanding rate of climb to extreme altitudes. Considerable experience has already been gained during extensive test-bed firing. Flight trials with the Spectre are scheduled for this summer.

VACUUM CLEANER FOR RADIO-ACTIVE DUST

Filters to 0·3 Microns

For collecting radio-active dust, a special type of vacuum cleaner has been designed and constructed by Hoover Limited, Perivale, Middlesex, to the requirements of the Atomic Energy Research Establishment, Harwell.

The cleaners are for use in laboratories or near atomic piles where there is the possibility of radio-active dust being present. To date, 80 of these special cleaners have either been supplied or are in course of supply for use at Harwell or at the U.K. Atomic Energy Authority's plant at Risley, Lancashire.

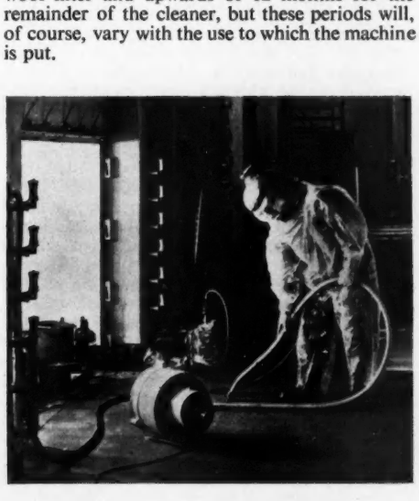
Basically cylindrical in shape, the machine stands 1 ft. 5 in. high and is 2 ft. 2 in. long by 1 ft. 3 in. wide. The exterior parts of the machine are of steel and moulded plastics and are coloured "signal red" as a warning of the possible radio-active contents of the machine.

The machine has two hoses of flexible plastic, having smooth bores to prevent adhesion of dust. The complete machine and its hoses are sufficiently water-proof to enable them to be hosed down with water for decontamination purposes.

The suction of the cleaner is obtained through a fan driven by a ½-h.p. commutator motor. These parts are as used in the firm's standard cylinder cleaners. The air, with its dust particles, is drawn into the machine through the cleaning tools and hose. The dust is collected in two replaceable filter units, the first of which uses a special cloth as a filtering medium, and the second of which uses a 1-in. thick wool pad impregnated with resin. The filtering units each consist of two 13-in. diameter moulded cones placed back to back with their filtering mediums clamped between the two. The action of these filters removes dust particles down to the size of 0·3 microns (0·00001 in.) A hose is available on the exhaust side of the machine for the controlled disposal of the filtered air, if desired.

During use, the dust particles adhere to the filter diaphragms or fall to the bottoms of the units, which are of such a design that they may be effectively sealed before removal from the cleaner, thereby protecting the operator from the radio-acitve dust.

Periodic checks are made to determine the radio-activity of the filters and machine, and replacements are made when necessary. The useful lives of the parts may be of the order of two weeks for the cloth filter, four weeks for the wool filter and upwards of 12 months for the remainder of the cleaner, but these periods will, of course, vary with the use to which the machine is put.



The special filter in this Hoover cleaner, designed to the requirements of Harwell, prevents any of the fine radio-active dust particles from escaping into the air.

LINEAR ACCELERATOR FOR RADIO THERAPY AND RESEARCH

AT THE MEDICAL COLLEGE OF ST. BARTHOLOMEW'S HOSPITAL, LONDON

By installing, in 1936, X-ray equipment in which the rays are generated at an energy of one million volts, St. Bartholomew's Hospital, London, can claim to be the first institution in Europe to enter the field of super-voltage therapy. This equipment has been in operation ever since and has been used for the treatment of over 3,000 patients. Since that time the value of super-voltage therapy has been universally recognised and has resulted in the employment of radiations of ever-increasing energy. These became available owing to the rapid progress made in nuclear physics, which resulted in the development of various types of accelerators capable of producing particles with very high energies, and also in the large-scale development of nuclear power and its by-products, the radioactive isotopes. The linear accelerator was found to have many important advantages for radiotherapy and several of these machines, with an energy of about four million volts, have been ordered by the Ministry of Health and have been, or are being, installed in British hospitals. One of these, installed in the General Hospital, Newcastle-upon-Tyne, was illustrated and described in ENGINEERING, vol. 177, page 694 (1954). The Medical Research Council, it may be added, has installed a linear accelerator operating at eight million volts. Betatrons, synchrotrons and other types of accelerator give radiations of even higher energy, and X-rays at up to 30-million volts have been employed in medical work, but, in general, the output from these machines is too low for use in routine radiotherapy.

INITIATION OF PROJECT

With these circumstances in mind, and desiring to keep in the forefront of radiotherapy, the Treasurer and Governors of St. Bartholomew's Hospital decided, in 1950, to install a machine which would embody the latest developments in the field and enable further progress to be made in the theory and practice of radiotherapy. After considering the various types of radiation generator available, they decided to acquire a 15-million volt linear accelerator since this combines high energy with high radiation intensity making it the most powerful machine available for treatment. This decision was reached after discussions with scientists from Harwell, who also decided to order a similar machine for research in nuclear physics. A contract was accordingly placed with Philips Electrical Limited, for a machine to be constructed at the Mullard Research Laboratories, Salfords, Surrey, the cost to be defrayed mainly from the Endowment Funds of the Hospital. This machine, which was completed in the autumn of 1954, and was illustrated and described in ENGINEERING, vol. 178, page 502 (1954), has since been installed in a temporary building in Charterhouse-square, adjacent, to the Physics Department of the Hospital, where it will be under the direction of the Professor of Physics, Professor J. Rotblat. The installation was formally inaugurated on Wednesday, April 27, by H.R.H. The Duke of Gloucester, who is President of St. Bartholomew's. Prior to the inauguration ceremony the installation was shown to a number of Press representatives who were also able to see some of the interesting apparatus to be used in the Physics Department for research work in connection with the accelerator.

NEW TECHNIQUES TO BE INVESTIGATED

The treatment of cancer by the high-energy X-rays generated in the linear accelerator is one of the chief objectives of the machine, but as two new techniques are possible with the accelerator these are to be investigated. One of them is electron therapy, in which the high-speed electrons are themselves used to irradiate the tumour. Electrons of 15-MeV energy can penetrate tissues to a depth of 3 in., their finite depth of penetration being a definite advantage. Neutron therapy is another technique which can be investigated with the aid of the linear accelerator, since a copious emission of neutrons can be obtained by causing the electrons to bombard uranium. The effects of the passage of neutrons through tissue may be quite different from those of X-rays, and an important point is that in certain cases it may be possible to localise the therapeutic action of the neutrons in definite regions of the body.

Above all, however, it is intended to use the accelerator for fundamental research into the action of radiations on living tissue, for which purpose the linear accelerator is particularly well suited owing to the pulsed character of the radiations it generates. The electrons are emitted in a series of short bursts each lasting about a millionth of a second, but within each burst the intensity of radiation is extremely high. It is thus possible to study the kinetics of the reactions produced, the speed at which the various secondary processes occur, and the effects produced by a greatly increased rate of radiation dosage. Such studies may lead to the discovery of new methods of protection from radiation as well as to improved techniques in radiotherapy.

MOVABLE X-RAY HEAD

The general arrangement of the accelerator and the principles upon which it depends for its action were explained in one of the articles referred to above. It will be remembered that the electrons are accelerated in a corrugated waveguide from one end of which they may emerge in a horizontal direction, or they may be deflected through a right angle by means of a magnet and emerge through the X-ray head which is attached to the end of the accelerator. This head, which is shown in the accompanying illustration, can be turned through an angle of 140 deg. in the vertical plane. It contains, in addition to the deflecting magnet, a target in the form of a disc of platinum which the electrons strike for the production of X-rays. In another position the rays strike a uranium cylinder, giving rise to the emission of fast neutrons. The X-ray head contains various ionisation chambers to measure the intensity of the electron beam and of the X-rays produced, and some of the ionisation chambers are arranged to control automatically the energy of the emerging radiations and to maintain constant the direction of the X-ray beam. The cross-sectional area of the latter, which is rectangular, can be adjusted by means of motor-driven lead blocks, the movement of which can alter the area from zero to 20 × 28 cm. at a distance of one metre. For treatment, the beam could be directed on to a patient by means of the X-ray head but very few, if any, patients will be treated during the next few years, during which the equipment will be devoted almost exclusively to research work.

PRELIMINARY TESTS

The accelerator can be operated from either of two control desks of which one, known as the physicist's control desk, is used only for starting up and for the initial tuning; the other, the radiographer's control desk, is provided with all the instruments and controls necessary for the normal running of the accelerator. Preliminary tests have now been carried out and have proved entirely satisfactory. When tuned to the optimum output the current in the pulse is about 50 milliamperes, which means

X-ray head of 15-MeV linear accelerator. Its purpose is to control the direction of high-energy electrons, X-rays or neutrons in radiotherapy and radiobiological research.

that the electron beam can deliver a dose of over 15,000 röntgens in a single pulse, having a duration slightly greater than one millionth of a second. At a repetition rate of 500 pulses per second this is equivalent to a mean dose rate of about 500 million röntgens per minute. Working at this frequency, the X-ray output was found to be 3,300 röntgens per minute at a distance of one metre, but correspondingly greater intensities are obtained at shorter distances. With these high outputs it will be obvious that for many experiments the time of exposure would be extremely short, much too short, in fact, to be controlled by a mechanical device such as a clock. Special electronic apparatus has therefore been designed and constructed in the Physics Department to enable the exposure to be terminated after any predetermined number of pulses, ranging from one to 10,000, and for many radiological experiments single-pulse exposures will be employed. In order to avoid possible variations in the intensity of individual pulses, which may occur when the accelerator is first switched on, a deflecting device has been included near the electron gun. This prevents the electron beam from passing through the accelerator until stable conditions have been attained.

PROPOSED RESEARCH WORK

In preparation for the research work to be carried out as soon as the tests of the performance of the accelerator have been completed, a number of experiments have been devised and the necessary equipment has been constructed in the laboratory and workshops of the Physics Department. One of the first experiments to be carried out will be an attempt to identify the short-lived chemical products formed as a result of irradiation. In particular, it is hoped to measure the lifetime of free radicals formed in irradiated liquids, by means of their absorption spectra. For this purpose, pulsed light sources have been developed of very short duration but of extremely high intensity, and in order to analyse the spectrum of the flash a high-speed rotating mirror, floating in a magnetic field without bearings, has been developed. In radiological research it is proposed to make an absolute determination of the energy deposited in irradiated tissue using a calorimetric method. Special calorimeters have been constructed to enable the energy absorbed in matter from X-rays

or electrons to be measured. Various ionisation chambers for electrons and X-rays have been designed and constructed to enable the radiations to be detected and measured. The investigations in nuclear physics to be undertaken will be concerned mainly with the disintegrations produced in various substances, and with the formation of radioactive elements as the result of bombardment with electrons and X-rays.

A contribution to the cost of the accelerator was made by King Edward's Hospital Fund for London, and the Treasurer and Governors of the Hospital desire to express their thanks for this, and to other organisations and individuals who have assisted the project in various ways.

* * *

LIGHTWEIGHT TRACTOR

A light two-wheeled tractor driven by a 147-cc. Mark 15 or 256-cc. Mark 25 Villiers four-stroke engine has been produced by the Raven Engineering Company, Limited, St. John's-road, Hampton Wick, Kingston-on-Thames. It is called the Farmer's Boy Major; the version with 147-cc. engine is intended for the small garden user, and that with the 256-cc. engine for the large-scale commercial grower or estate owner. Apart from the engines, which are interchangeable, the machines are identical and will operate the same range of attachments. The speed range is from ¾ to 5 m.p.h., and the track width can be varied from 15 in. to 36 in. Adjustable spring-loaded pawls are fitted to the wheel hubs enabling either or both wheels to be freed from the transmission as required by the operator. The disc-type wheels are fitted with 4·00 by 12 in. heavy-duty tractor tyres, over which steel cleated rims can be bolted for ploughing, as shown below.

Provision has been made for the tool bar to be mounted either at front or rear of the tractor; the equipment is fixed by two set bolts and secured by a self-locking tommy bar. Equipment includes a heavy-duty single-furrow plough, with a claimed ploughing depth of 8 in. to 9 in.; 20 in. single and 30 in. twin rotary scythes, reciprocating cutter bar, 12 in. and 17 in. rotary hoes, cultivating tines, hedge trimmer, disc and chain harrows, furrower, single ridger, and saw bench.

The tractor can be fitted with a 147-cc or 256-cc. engine. The steel-cleated rims are bolted over the heavy-duty tractor tyres.

Labour Notes

INTER-UNION DISPUTE

What appears to be largely a dispute between the National Amalgamated Stevedores and Dockers and the Transport and General Workers' Union has developed in the dock industry.

It was announced on May 16 that notices calling for a stoppage of work by dock employees at London and the northern ports had been issued by the executive committee of the N.A.S.D. and that members of that union were due to come out on strike as from next Monday.

Meetings of members of the N.A.S.D. at Hull, Birkenhead, Liverpool, London and Manchester, held at the end of last week, voted in favour of strike action being taken on a national basis, to enforce the union's claim to be recognised as a fully-negotiating body at northern ports. Until a few months ago, the N.A.S.D. restricted its activities to London and only the T.G.W.U. has been represented on local joint committees of the dock industry at other British ports.

Following the recruitment of new members by the N.A.S.D. during recent months, however, considerable dissatisfaction is stated to have grown up in that union, owing to its not having been permitted to elect representatives on to local joint committees of employers and dockers, and thus become fully recognised as a negotiating body at northern ports, as well as in London.

EMPLOYERS' ATTITUDE

It may be recalled that the recruitment of members by the N.A.S.D. was claimed to have been largely carried out during a previous dock dispute and that the T.G.W.U. had alleged that this action constituted "poaching" and was a violation of inter-union agreements.

After an investigation, the Trades Union Congress declared the N.A.S.D. to be at fault and suspended the union from its affiliation to the Congress. This action may now have the result of making it very difficult for the T.U.C. to intervene in the dispute as it did in the case of the newspaper stoppage and the threatened strike of the railway-footplate men.

How far members of the T.G.W.U. are likely to become involved in strike action remains to be seen. Apart from their reluctance to handle "black" cargoes, there are many instances in the industry of gangs being composed of members of both unions, and the unwillingness of dock employees to work without a full complement to their gangs is well known.

When members of the N.A.S.D. ceased work in March as a protest against a refusal to issue them with registration books, which every docker needs to enable him to obtain work, some thousands of members of the T.G.W.U. came out on strike, although the dispute had nothing to do with them.

A statement issued by the National Association of Port Employers last week confirmed that the N.A.S.D. wrote to the employers' side of the local joint committees at Hull, Liverpool and Manchester asking for representation at those ports. The employers' view, which was communicated to the union, was that, while it was important for the local joint committees to be representative of both employers and dock workers, the constitution of the workpeople's side was essentially a matter for trade unions to determine for themselves.

MERSEY TUG STRIKE ENDED

The strike of tugmen on Merseyside, which had brought shipping at Liverpool to a virtual standstill for a week, came to a sudden end on May 12, when the men returned to work in force.

A mass meeting of the tugmen on the previous day decided upon this course by 236 votes to 235. No casting vote was used and the men, having previously agreed to abide by the result of the count, stood by their decision.

It was announced subsequently by Mr. Tom Burkett, the national secretary of the waterways section of the Transport and General Workers' Union, to which the men belong, that the meeting had agreed to return to work on the understanding that they would be supported by the full strength of the union in their endeavours to obtain the remaining concessions claimed by them. These are a shorter working week and higher payments for overtime.

The Liverpool Tug Owners' Association stated on May 10 that it had conceded seven of the nine demands made by the tugmen and that it was unable to agree to the two remaining claims, but was prepared to submit them to arbitration.

Towards the conclusion of the stoppage, all the 600 tugmen in the area had withdrawn their labour and about 80 ships were idle in consequence. On the last day of the strike, the number of dockers laid off and placed in the reserve labour pool increased to 5,128, about one-third of all dock workers employed on Merseyside.

YORKSHIRE COAL STRIKE

Normal working was resumed at all pits in the Yorkshire coalfield on Monday after the unofficial strike over fillers' rates and allowances, which began at Markham Main Colliery three weeks previously.

The Doncaster miners' panel met last Friday and recommended the 27,000 miners on strike at the 13 collieries in their area to resume work on the basis of an offer contained in a letter from the North-Eastern Division of the National Coal Board, which put forward proposals for settling the fillers' price-list grievances.

These were the men who originally came out on strike in support of the miners at Markham Main Colliery. Men at collieries in other areas followed. The strike at a few collieries in the North Staffordshire area ended last Friday on the understanding that the N.C.B. would examine price lists at all pits in the area, with a view to the introduction of a basic wage of from £2 10*s.* to £3 a shift for the men concerned.

The strike, which is considered to have been the most wasteful to occur in the industry since 1926, has resulted in the loss of 1,030,860 tons of coal, at a time when the country is importing large quantities from abroad, and has cost the miners over a million pounds in wages.

MINERS' NEW PAY RATES

New wage scales affecting about 380,000 day-wage men at British collieries were introduced recently and the men in question drew their first week's wages under the revised regulations last Friday.

The scheme, which is regarded by the men's union as "a great experiment," ensures that all pay packets are made up on the same national basis, according to the work performed and the man's own grade. Standard and maximum rates are provided for each grade. The average increase for men employed on the minimum rates works out at about 1*s.* 11*d.* a shift, but miners earning more than these rates are expected to receive only an extra shilling a shift.

Apart from some pits in Scotland, where strikes have arisen, few complaints have been reported. It is expected to be at least another month before the new system is fully understood and accepted by all the miners.

EFFECT OF HIRE-PURCHASE CONTROLS

Some redundancy has been caused at Wolverhampton owing to the recent imposition of more stringent controls on the operation of hire-purchase agreements.

There is stated to have been a serious decline in the sale of gas cookers in the home market, owing to these controls, and, in consequence, there is insufficient work for nearly 200 persons employed by Cannon Industries, Limited, Coseley, Staffordshire. These workpeople were laid off as from the end of last week.

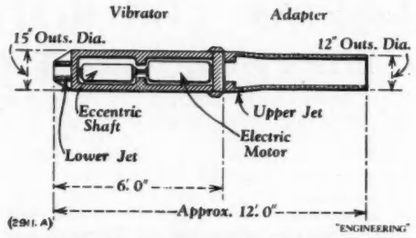
A few days ago, a representative of the company condemned the controls as being, in effect, rationing by the purse. Whereas the deposit required by many local gas boards for cookers produced by the firm was from 20*s.* to 50*s.* before the controls came into force, the amount required had since been raised to £9 per appliance. The firm, it was stated, had planned to erect a new factory to produce cookers for export.

COMPACTING GRANULAR SOILS

Vibrated in Saturated State

A technique for compacting granular soils by the combined use of mechanical vibrations and the simultaneous saturation of the soil with water was invented by Sergey Steuerman in Germany about 1935. The granules of the soil mass are "floated" and shaken into a dense state by a "Vibroflot"—a machine which consists primarily of an electrically-driven vibrator and is driven into the ground under its own weight, aided by a high pressure jet issuing from the nose of the machine. Since its invention the process has been used in Germany and some other European countries and, since 1945, in the United States. The exclusive licence rights on the process in the United Kingdom and for some overseas areas have recently been obtained by a British company, Vibrofounds, Limited, Ruislip-road, Southall, Middlesex.

The Vibroflot, about 6 ft. long and 15 in. in diameter, consists, as already stated and shown in the cross-section, of an electrically driven vibrator to which is attached an adaptor and a 12-in. diameter follow-up pipe. As shown in the second illustration, the machine is suspended from a crane over the point to be compacted and the motor is started. When the motor attains full speed the bottom jet is opened, so providing a pool of water and a saturated mass of soil for the Vibroflot to penetrate. With the jet full open, the machine is allowed to sink into the soil under its own weight, the combined action of the vibration and the upward flow of the water producing a "quick" condition enabling it to penetrate easily.



The "Vibroflot" penetrates into the soil assisted by the lower jet. When sufficient depth has been reached it is withdrawn using the upper jet.

When the machine has reached the required depth, the water supply is transferred from the jet in the nose of the Vibroflot to jets in the adaptor section. As the machine is withdrawn the combined action of the vibrations and the downflow of water continues the compaction process that was commenced during penetration. A ready measure of the compaction attained is available from the power being consumed—the denser soil having more resistance to movement so that more power is required to maintain the initial frequency of vibration.

Using the technique described, a cylindrical column of compacted soil of up to 10 ft. in diameter is produced; by suitably arranging the points of compaction in sufficiently close proximity to obtain overlap between adjacent columns, a fully-compacted sub-soil of unlimited extent can be constructed. A minimum thickness of 8 ft. is considered necessary for the process to be economical, but a depth of 12 to 30 ft. is the usual working range and compaction depths of 35 to 50 ft. have been obtained. "Vibroflotation" has many possible applications, in particular for foundations for buildings, chimneys or heavy vibrating machinery. It is also suitable for strengthening the sub-soils below airport runways, roads and parking aprons. The technique can also be used effectively under water.

The machine is suspended from a crane and penetrates the soil under its own weight. A column of compacted soil of 10 ft. diameter is produced, up to a maximum of 50 ft. depth.

★ ★ ★

13-AMPERE SOCKET OUTLETS

A range of 11 flush surface-mounting 13-ampere three-pin socket outlets has been introduced by J. A. Crabtree and Company, Limited, Lincoln Works, Walsall. They are available in shockproof or metal-plate types, switched or unswitched.

In the metal units the plate is of the "raised" type, thus providing considerably more wiring space than can be given by flat-plate accessories. At the same time, a large intermediate moulding not only serves to shroud the current-carrying socket tubes but also provides an adequate flat bearing on the plaster, taking the full pressure from the two plate-fixing screws and allowing the edge of the metal plate to make easy contact with the wall.

The switch incorporates rigid silver-inlaid contacts; indirect friction-free roller action; and a shrouded mechanism. In addition, the switch has a moulded nylon dolly which is virtually unbreakable.

The shield guarding the socket-outlet openings is formed of flat fibre and is operated through a cam by the earth pin, the mechanism being very lightly spring loaded. The cam is of nylon material and moves with a minimum of friction and wear. Since the plug pins do not come into contact with the shield, this again is subject to little wear and will last almost indefinitely.

The shutter-operating cam has been designed to clear the earth pin, while all three pins are machined to close limits to ensure an intimate engagement with the socket tubes. The result is excellent electrical continuity and a smooth action between plug and socket-outlet.

NOTICES OF MEETINGS

Chemical Engineering Group

LONDON
Annual General Meeting. Café Royal, Regent-street, W.1. Fri., June 3, 6.15 p.m. (To be followed by the annual dinner.)

Chemical Society

LONDON
Centenary Lecture on "Chemical Effects of Steric Strains," by Professor H. C. Brown. Thurs., June 2, 7.30 p.m.
SHEFFIELD
Centenary Lecture on "Chemical Effects of Steric Strains," by Professor H. C. Brown. Sheffield Branch. Chemistry Lecture Theatre, The University, Sheffield. Mon., May 23, 7.30 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Steam in Industry," by L. A. Bawden. Birmingham Branch. Imperial Hotel, Birmingham. Fri., May 27, 7.30 p.m.
SHEFFIELD
Discussion on "Illumination." Sheffield Branch. Grand Hotel, Sheffield. Thurs., May 26, 7.30 p.m.

Institute of Physics

GLASGOW
Summer Meeting, Non-Destructive Testing Group, Royal Technical College, Glasgow. Wed., June 22, to Sat., June 25. Assembly, Wed., June 22, 8 p.m.
Annual General Meeting; "Training for Radiography," by T. S. Wylie; "Shipyard Radiography," by E. J. Duffy; and "Non-Destructive Testing in the Boilermaking Industry," by W. G. Marskell, at 9 a.m. "Surface Properties: Their Possible Use in the Testing of Materials," by Dr. R. W. B. Stephens; and "The Physical Meaning of Indentation and Scratch Hardness," by Dr. D. Tabor, at 2.15 p.m. Supper at 7.15 p.m., Thurs., June. 23.
"An Assessment of Ultrasonic Techniques, with Special Reference to Welds," by H. L. Carson; and "Problems in the Interpretation of Ultrasonic Tests on Steel," by I. M. MacKenzie and R. Kennedy, at 9.15 a.m. Works Visits and Evening Excursion, from 1.30 p.m. onwards, Fri., June. 24.
"Neutron Radiography," by Dr. J. Thewlis and R. T. P. Derbyshire; and Discussion on "Research Work Required to Promote Progress in the Field of Non-Destructive Testing," opened with a paper on "The Scope of Non-Destructive Testing," by Dr. E. G. Stanford. Sat., June 25, 9.30 a.m.

Institution of Chemical Engineers

LONDON
Address on "Mechanism of Fluidisation of Powders in Gases," by Professor Warren K. Lewis. Royal Institution, 21 Albemarle-street, W.1. Tues., May 24, 5.30 p.m.

Institution of Civil Engineers

LONDON
James Forrest Lecture on "Nuclear Power and World Energy Resources," by Sir John Cockcroft. Tues., May 24, 5.30 p.m.
Annual General Meeting. Corporate members only. Tues., June 7, 5.30 p.m.

Institution of Mining and Metallurgy

LONDON
Annual General Meeting, open to corporate and non-corporate members only, at 4 p.m. Presidential Address by Mr. Stanley Robson, at 5.15 p.m. Apartments of the Geological Society, Burlington House, Piccadilly, W.1. Thurs., May 26.

Institution of Production Engineers

SHREWSBURY
"The Manufacture of Springs," by J. A. Roberts. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., May 25, 7.30 p.m.
WOLVERHAMPTON
"Practical Approach to Engineering Fine Surfaces," by D. B. Ebsworth. Wolverhampton Section. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., May 25, 7.15 p.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Wed., May 25, 6 p.m.

Royal Institution

LONDON
"Weather Forecasting: The Future Outlook," by Sir Graham Sutton. Fri., June 10, 9 p.m.

Royal Society

LONDON
Discussion on "Radiative Balance in the Atmosphere," to be opened by H. S. W. Massey. Thurs., June 9, 11 a.m.

Royal Statistical Society

LONDON
"A Unified Derivation of Some Frequency Distributions of Importance in Biometry and Statistics," by Dr. J. O. Irwin. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 25, 5.15 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting and Presidential Address. Manson House, 26 Portland-place, W.1. Tues., May 24, 6 p.m.

Women's Engineering Society

MANCHESTER
Annual General Meeting and Film Evening. Manchester Branch. Engineers' Club, Albert-square, Manchester, 2. Wed., June 8, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (NATional 0621.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Instrument Technology, 184 Sherwood Park-road, Mitcham, Surrey. (POLlards 3620.)
Women's Engineering Society, 45 Eastcastle-street, London, W.1. (LANgham 9571.)